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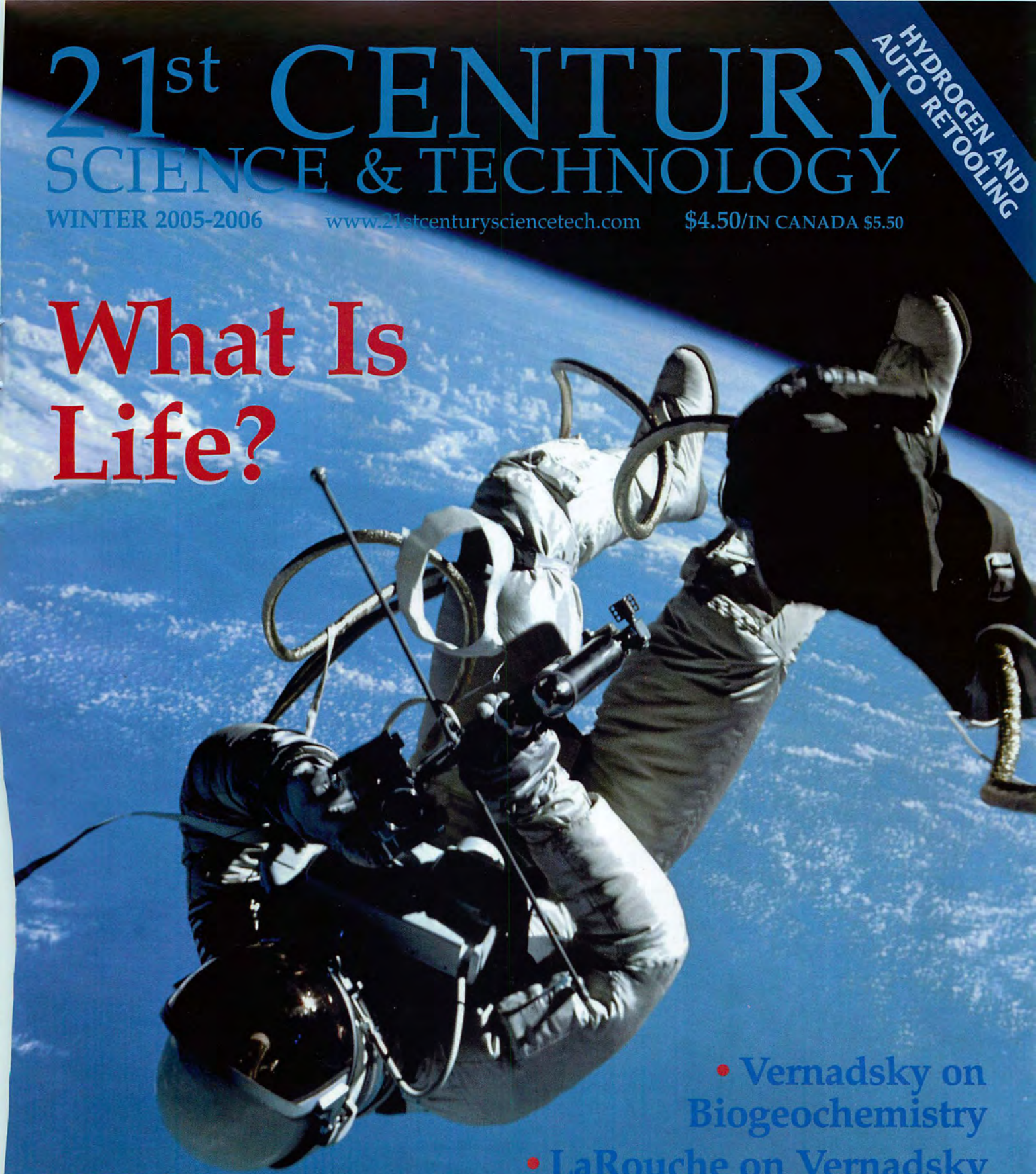

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21st CENTURY SCIENCE & TECHNOLOGY

Vol. 18, No. 4 Winter 2005-2006

Science & The LaRouche Youth Movement

Features

NASA Marshall Space Flight Center

Hydrogen and Auto Retooling: *The U.S. auto industry produced rockets and missiles for NASA, and can be retooled for many other products. See Editorial and Special Report (p. 64). Here, the Chrysler-built Saturn IB first stage, in a test version at Marshall Space Flight Center.*

News

Departments

On the cover: Edward H. White II, pilot of the Gemini 4 spacecraft, floats in space on June 3, 1965, the first time an American stepped outside the confines of his spacecraft. Photo courtesy of NASA; cover design by Alan Yue.

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Hydrogen: First Element of Economic Recovery

A breakthrough in a high-energy laser program at a U.S. national laboratory about a decade ago has implications for ending the world's dependence on dwindling oil and gas supplies, and for a new future for the American automotive industry.

Using the capabilities of extremely rapid pulse lasers, it should soon be possible to machine and case harden ceramic turbine blades that could operate at temperatures near 3,000° Celsius. At such high temperatures, small ceramic turbines could achieve efficiencies of 80 percent, several times that of ordinary internal combustion engines. At such efficiencies, a tank of compressed hydrogen of the same volume as the fuel tank on a car, truck, or airplane could provide the range now achieved with gasoline, or aviation fuel.

Hydrogen can be cheaply produced in the new generation of high-temperature nuclear reactors using water as the only raw material, and thus the dream of a portable fuel to replace our dependence on imported petroleum would be realized by a succession of new technological applications.

Yet, the high-temperature ceramic turbine is just one of the possible applications of a new physical principle demonstrated by the Petawatt (1.25 quadrillion watt), femtosecond (.000000000000001 second) pulse laser, first fired at Lawrence Livermore National Laboratory on May 23, 1996. Because of its ability to remove extremely thin layers of material with no heating or other damage to neighboring material, smaller-scale versions of these rapid pulse lasers are already finding routine use in Lasik eye surgery and in precision machining applications in industry.

When the laser beam passes over or through a material, its intense charge pulls off the surface electrons and creates an electron plasma which prevents further heating or other damage. By mastering the physics of this plasma, researchers in laser machining have found ways to use slower, but more workable, nanosecond lasers to precision machine materials—one molecular layer at a time—using the new "double pulse" method.

One of the most remarkable discoveries of the Livermore program was that antimatter was being produced, when the Petawatt beam hit a heavy atom such as gold, knocking off electrons at relativistic velocities. Study of the target assemblies showed that high-energy proton beams were also being generated, perpendicular to the rear surface of the laser target. The femtosecond petawatt laser was carrying out functions only seen before in powerful particle accelerators!

Yet the Petawatt laser program at Livermore was shut down on May 27, 1999. The justification was to make way for the higher power lasers of the National Ignition Facility (NIF). This program, which was to bring us closer to the realization of thermonuclear fusion energy by laser compression of hydrogen-isotope fuel pellets, was to be completed in 2003. It never was, and remains bogged down in Congressional wrangling. To see what an error this was, consider the following.

Hydrogen and Nuclear Power

In the near future, most of the world's electricity will be coming from the new generation of high-temperature gas-cooled nuclear reactors, which evolved from the pebble bed reactor first operated at Julich, Germany in 1958. Factory-scale modular production of reactors in the 125 to 250 megawatt range will be possible for export to developing nations, and for use in series at large power stations. The General Atomics Gas Turbine Modular Helium Reactor (GT-MHR), under development by the San Diego-based firm in Russia, and the South

African Pebble Bed Modular Reactor (PBMR) are the leading candidates.

The high operating temperature of this new-generation reactor greatly increases the efficiency of energy conversion. At temperatures of 750° Celsius and higher, readily attainable in high-temperature nuclear reactors, the water molecule can be broken apart with great efficiency both by electrolysis and by a number of chemical cycles. (One of the most promising is the sulfur-iodine process.) At temperatures of 900° C., the efficiency of conversion of heat to hydrogen can reach 50 percent or higher.

The hydrogen fuel is produced at the power plant, which will be in the vicinity of population centers where it is consumed, not thousands of miles away at the site of an oil or gas well. The cost, danger, and potential for geopolitical conflict of transporting petroleum thousands of miles across oceans is thus eliminated.

Hydrogen gas burns in air, leaving only water vapor as its by-product, which is returned to the Earth as dew, rain, or snow. In every molecule of water there are two parts hydrogen, so we have a virtually unlimited and completely renewable supply of portable energy. The wasteful use of oil and natural gas for electricity generation and home heating can be almost completely eliminated by expansion of nuclear electricity production. The primary use for hydrogen in a modern economy will be in transportation, to provide the power for vehicles, such as cars, trucks, and aircraft, that cannot be tied to an electrical line.

Hydrogen can also be used as the power source for a fuel cell, a device which catalytically combines hydrogen and oxygen gas to produce electricity, a sort of electrolysis in reverse. Experimental fuel cell-driven automobiles and other vehicles are already operating. Presently, the cost of fuel cells is high, but it will go down with mass production. The main drawback so far has been the difficulty of storing an amount of hydrogen sufficient to give the vehicle a useful range. A variety of novel methods of hydrogen storage are being researched, including storage in carbon nanotubes (buckyballs), and a new method pioneered at the Danish Technical University, using an ammonium compound to hold the hydrogen.

The Lesson to Be Learned

Whether the high-temperature turbine, the fuel cell, or some other means proves to be the best replacement for petroleum in vehicles remains to be seen. We hope and predict that a variety of methods will be tried and tested before the best one is found, and that great fun will be had in the process.

But a principle is at work here, which goes beyond the immediate practical implications of the hydrogen economy. The principle illustrated by the unexpected laser-cutting spinoff of the Petawatt laser is that the solution to a technological problem is most often found, not in what is known by specialists at any given time, but in some unexpected discovery at the boundaries of existing knowledge, and often in a new regime of higher energy densities or other extreme conditions.

The historic firing of the first beam from the Petawatt laser at Lawrence Livermore in 1996 opened up a new and important part of the scientific-technological revolution that we and our predecessor *Fusion* magazine have been calling for since the 1970s. There must be more of it, as we move ahead into the 21st century.

—Laurence Hecht

AIDS Not Slowing Down

To the Editor:

Your articles in the Winter issues of 1997 and 1998 and others show falling growth rates for the world population, with falling total number of world population in 2000 and 2025, all depending on AIDS.

What is the situation in 2005? Is the AIDS situation still accelerating the falling growth rates? . . . A very important question is, if it is possible to get the AIDS epidemic under control with the limited resources (as I see it), which are given by the rich countries.

I hope that you will cover this subject, also with economic aspects, in forthcoming issues.

Lars-Olof Johansson

Colin Lowry Replies

The AIDS epidemic (actually a pandemic) has shown no signs of slowing down, and according to the UNAIDS program report released in December 2005, there are now 40.3 million people living with HIV worldwide. The numbers of new infections are still increasing, as 5 million people became infected last year. The hardest hit area remains sub-Saharan Africa, where in six countries the HIV prevalence among pregnant women is over 20 percent, and in two it is over 30 percent, ensuring that the next generation will be virtually wiped out by the combined effects of the deadly epidemic, the huge economic losses, and lack of adequate nutrition.

Funding for basic AIDS treatment and prevention has been woefully inadequate. Approximately $6 billion was spent worldwide last year. The U.N. Global Fund estimates that at least $12 billion was needed last year for AIDS programs, and this year the shortfall in funding may exceed $8 billion. These amounts do not take into account the need for health, sanitation, and other infrastructure in the areas of Africa and Asia that are suffering the most. Even in the United States, there has been no reduction in new infections for the past few years, and conservative estimates put the number of infected persons at more than 1 million. Although much of the media has been touting the effectiveness of the new HIV drugs, less than 10 percent of the people worldwide who need antiviral treatment can actually get these drugs.

Correction

Charles Hughes's article on telescope making (Fall 2005), did not invent a new polygon! The description of the tube making (p. 68) describes regular *octagons* and an octagonal bulkhead (not hexagons and a hexagonal bulkhead).

Teollisuuden Voima Oy

Finland's 1,600-MW Pressurized Water Reactor, being built by Areva and Siemans, is scheduled to be on line by 2009.

Indian Malaria Eradication Programme

An anti-malaria poster circa 1960. When DDT spraying was stopped after the U.S. banned it in 1972—for political reasons—malaria returned as a major killer in tropical countries.

MILLION-MEMBER BRITISH LABOR UNION CALLS FOR NUCLEAR POWER

Derek Simpson, leader of the million-member Amicus union, has made an unprecedented call for new nuclear generators in January, in the face of soaring energy costs. Amicus represents all of Britain's manufacturing sector, including steel, auto, aerospace, energy, construction, shipbuilding, food, paper, and other manufacturing. Amicus officials are planning a campaign to educate the public about a growing energy crisis.

After many years of being self-sufficient in coal, oil, and natural gas (in addition to being 23 percent nuclear), Britain has suddenly become a net importer of gas. Simpson warned as early as Sept. 13, 2004 that Britain could face blackouts in 2005, and rising prices. "The main reason given for outsourcing production by manufacturing companies in the U.K. is no longer labor costs; it's high energy costs." Support for nuclear power lines Amicus up with the employers and the Confederation of British Industry (CBI), whose head, Sir Digby Jones, recently called energy prices the "biggest immediate issue facing British business."

In France, President Jacques Chirac announced that France would approve development of a fourth-generation nuclear plant, to come on line by 2020. In the meantime, a joint project between France and Germany is expected to bring on line a third-generation pressurized water reactor by 2012. Finland is now constructing its fifth nuclear power plant, the first new nuclear plant in Europe in a decade, which is scheduled to be on line in 2009.

DANISH RESEARCHERS DISCOVER 'HYDROGEN PILL'

A team of scientists at the Danish Technical University have discovered a simple means of reducing the volume of hydrogen which would be carried on vehicles powered by fuel cells, or other hydrogen-consuming devices. Hydrogen is an ideal candidate for replacing petroleum dependency. It burns cleanly leaving only water vapor as a byproduct, and it can be produced efficiently by chemical separation or electrolysis of water in the new generation of high-temperature nuclear reactors.

The key problem for hydrogen-powered vehicles has been to find an efficient means of storing the gas. The Danish technique is to store the hydrogen locked up in ammonia (NH_3) in the form of a solid "pill." The pill is made of ammonia absorbed in magnesium chloride, an ingredient of ordinary sea salt. Ammonia can be catalytically formed by combining atmospheric nitrogen with hydrogen. The pill can be stored indefinitely, and the hydrogen is first released after the ammonia is funnelled into a catalyzer. After the pill is emptied of its hydrogen, it just needs a new shot of ammonia, and it is again ready for use. The discoverers claim the pill will permit a volume equivalent to a normal fuel tank to give a car a range of 600 km (375 miles). The hydrogen pill was developed by five researchers from the Denmark Technical University: Jens Noerskov, Claus Hviid Christensen, Tue Johannessen, Ulrik Quaade, and Rasmus Zink Soerensen.

MALARIA INCREASES TRANSMISSIBLITY OF AIDS TO NEWBORNS

Accumulating statistical evidence has suggested that mothers with both HIV (AIDS virus) and malaria are more likely to pass HIV on to their children. Findings, presented at the Fourth Multilateral Initiative on Malaria conference in Yaoundé, Cameroon in November 2005, show a mechanism for it.

Researchers from the Pasteur Centre in Yaoundé found that pregnant women with malaria produce more of a chemical (TNF-alpha) in their placentas which stimulates HIV replication. They hypothesize that this increased replication in the placental region increases the likelihood of the virus crossing the placental barrier to the fetus. Because concurrent malaria and HIV infection affects millions of women of reproductive age in some areas of Africa, the increased threat to the unborn generations of Africans is huge.

Spraying the inside walls of houses with DDT is the most effective and safe way to cut the incidence of malaria. Although it is used in several African countries, Malthusian and environmentalist propaganda is still preventing its use in Nigeria, Uganda, and other African nations.

7,000 YEAR-OLD OBSERVATORY REOPENED IN GERMANY

The stone-age observatory at Goseck, in the state of Saxe-Anhalt in Germany, which was discovered by aerial archeography in 1991 and reconstructed to its original shape, was reopened for visitors in December. The two main rings of palisades, the gates of which point exactly to the sunrise at solstice, form what is known to date, as the oldest observatory in the world. The ancient structures were dated as older than 6,800 years, which is older than the Stonehenge site in England, and older than the pyramids in Egypt.

The original site may have been in use until 800 B.C., which means that its reopening today, with a Winter solstice ceremony, occurs after an interruption of almost 3,000 years. The entire site is surrounded by numerous larger settlements dating from the Stone Age, as well as by other structures that indicate rather developed astronomic practices, several thousand years ago. Not far from Goseck, a Bronze-Age plate depicting a section of the sky along with two curves, likely portraying the movement of the Sun between the two annual solstices, was found, in 1997. (See fuller report in Fall 2005 *21st Century*).

Landesmuseum für Vorgeschichte Sachsen-Anhalt

The reconstructed Goseck Solar Observatory in northern Germany.

LIVING PLANTS DISCOVERED TO BE MAJOR SOURCE OF METHANE

According to new research, plants produce 10 to 30 percent of the annual methane found in the atmosphere. Previously it was thought that plants only emitted methane when decaying in an oxygen-free environment. But a team led by Dr. Frank Keppler at the Max Planck Institute for Nuclear Physics in Heidelberg has observed 10 to 100 times more methane coming from living plants than from dead ones, according to a report in the journal *Nature,* Jan. 12, 2006.

Methane is more effective than carbon dioxide in allowing warming solar radiation in and preventing its reflection back into space (the "greenhouse effect"). One kilogram of methane has the greenhouse power of 58 kilograms of carbon dioxide, according to Dr. Gerd Weber in *Global Warming: The Rest of the Story.* Whether significant global warming is really caused by industrial and human pollutants remains a point of controversy, as our readers are aware. Now it looks like just shutting down power plants won't be enough to satisfy the Kyoto protocol, which calls for a 5.2 percent reduction in greenhouse gas emissions below 1990 levels in the next six years.

BORLAUG WARNS OF COMPLACENCE, AS WHEAT RUST SPREADS

Agriculture experts from around the world met in Nairobi, Kenya, on Sept. 9, 2005 to sound the alarm on a threat to future world supplies of wheat. A variety of wheat stem rust (*Puccinia graminis*) called Ug99, which emerged in Uganda in 1999, has shown surprising virulence in most of the commonly grown varieties of wheat. The fungus has already spread throughout eastern Africa, and the spores, which are adapted for wind dispersal, will soon spread the rust even further.

Norman Borlaug, the 91-year-old Nobel laureate who fathered the Green Revolution, said at the meeting: "Nobody's seen an epidemic for 50 years, nobody in this room except myself. . . . Maybe we got too complacent." Recent questionnaires to wheat breeders have shown that rust resistance is no longer a top priority in their breeding programs. They are still relying on the varieties developed by Borlaug and others almost 50 years ago. Borlaug thinks the fungus will particularly hurt the small farmer in the developing world, who can't afford the fungicides routinely used by agribusiness in developed countries.

From 1950-1954, the United States suffered its last disastrous wheat rust epidemic. Borlaug noted in an expert report prepared for the meeting by CIMMYT (*Centro Internacional de Mejoramiento de Maíz y Trigo*), that during the 1960s and 1970s, there was more focus on developing disease-resistant strains, and more communication among agricultural scientists of various nations. Participants at the Nairobi meeting formed a new international organization, the Global Rust Initiative, to monitor the disease and to coordinate development and testing of new rust-resistant varieties of wheat.

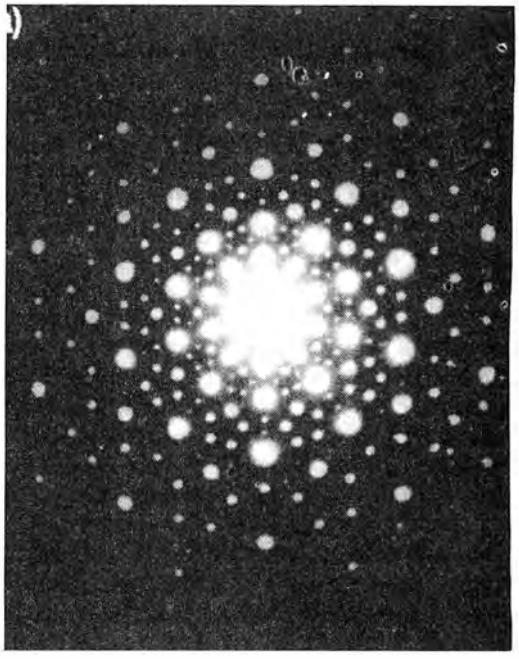
Norman Borlaug Heritage Foundation

Norman Borlaug, father of the "Green Revolution," still fighting, at age 91, to feed the world's population.

A Keplerian Solution to The Quasicrystal Problem

by Laurence Hecht

December 26, 2005



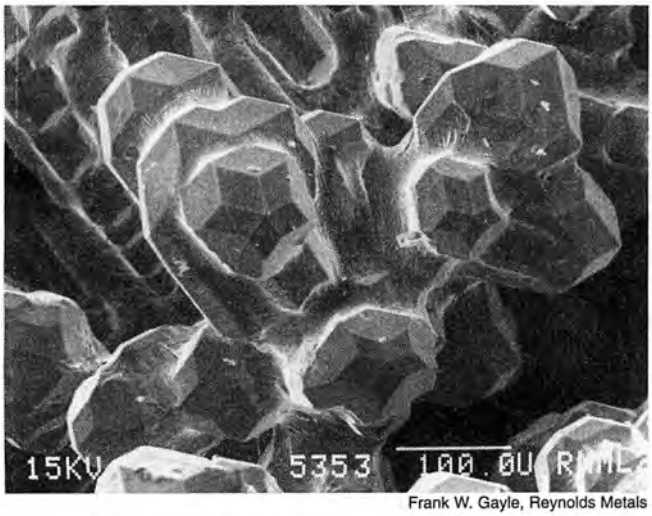
Evidence of five-fold symmetry first appeared in 1984 in samples of rapidly quenched aluminum-manganese alloys obtained by Dany Shechtman, et al. These produced diffraction patterns like the one at right, in which 10 points surround a central one in a decagonal pattern.

The discovery in 1984 of an aluminum-manganese alloy showing the "forbidden" pentagonal symmetry created a crisis in crystallography, and implicitly in all physical science, which has not been satisfactorily resolved. So far, attempts to explain how it is possible for a lattice to show quasi-periodic symmetry have required recourse either to a structure made up of several different unit cells, or to mathematical modelling of multidimensional space. Neither appears satisfactory to me.

By re-examining one of the fundamental assumptions of crystallography, returning to the method of Johannes Kepler in his *Six Cornered Snowflake,* I have found a simple means of constructing a three-dimensional lattice of pentagonal symmetry. By varying one of the traditional axioms of crystallograpy to permit interpenetration of the cells, a regularly repeated dodecahedral or icosahedral unit cell may fill space, producing a self-similarly enlarging dodecahedron or icosahedron. From this it may be seen how a crystal of five-fold symmetry might grow. It is beyond my means presently to verify whether any of the variety of known quasicrystals corresponds to this construction. I put forward this hypothesis as a contribution to the search for an explanation to this interesting new phenomenon, which will serve in any case as a construction of geometric interest.

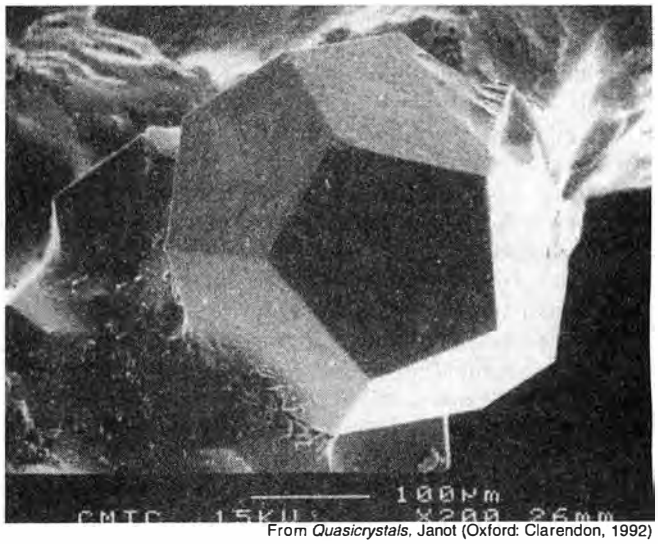
Pentagonal 'Tiling'

My solution derives from a construction for creating self-similar plane pen-



Frank W. Gayle, Reynolds Metals

Crystals of an aluminum-copper-lithium alloy (Al_6CuLi_3) obtained in 1986 showed the shape of the rhombic tricontahedron, with single grains approaching a size of 1 millimeter. The figure, discovered by Kepler and reported in his work The Six-Cornered Snowflake, consists of 30 rhombuses whose diagonals are in the golden ratio.



From *Quasicrystals,* Janot (Oxford: Clarendon, 1992)

An almost millimeter-sized single grain of an AlCuFe alloy. Dodecahedral crystals of aluminum-iron-copper alloy were first obtained in 1988, followed by aluminum-palladium-manganese in 1990. They were formed by regular slow-casting methods and behaved stably.

tagons. I discovered this construction one day while contemplating the meaning of a fragment from Diophantus' lost work "On Polygonal Numbers," which describes a proposition by the classical Greek geometer Hypsicles:

"There has also been proved what was stated by Hypsicles in a definition, namely, that 'if there be as many numbers as we please beginning from 1 and increasing by the same common difference, then, when the common difference is 1, the sum of all the numbers is a triangular number; when 2, a square number; when 3, a pentagonal number [; and so on]. The number of angles is called after the number which exceeds the common difference by 2, and the sides after the number of terms including 1.' "[1]

The problem of the quasicrystal is related to the so-called "tiling" problem (how to cover the plane by repetition of like shapes). However, the solution arose by considering the crystallographic problem from the standpoint implied in the Diophantus fragment: How to create self-similarly growing figures? Self-similar squares and triangles may be produced from square and triangular tiles in a manner that is fairly easy to see. The squares completely cover the area they enclose. The triangles leave holes, also of triangular shape, and thus the principle of tiling (that the plane be completely covered) is modified (Figure 1).

To construct self-similar pentagons, it is necessary to modify the principle of tiling in the opposite direction—that is, to allow the pentagons to overlap and thus to "overfill" the plane. By such means, a succession of self-similar regular pentagons consisting of 1,5,12,22,35, . . . pentagonal units may be constructed (Figure 2). The second-order difference of the series of pentagonal numbers so constructed, is, as Hypsicles noted, 3; that for the square numbers is 2; and for the triangular numbers, 1.

Hypsicles' expressed concern with the triangle, square, and pentagon suggested to me that he must have been investigating the five regular or Platonic solids, whose faces are restricted to these three polygons. From that consideration, I saw that there existed constructible mathematical functions, analogous to what we are familiar with as "squared and "cubed," for each of the Platonic solids.

Thus, on the base of the plane figure "2-triangled," one may construct the solid "2-tetrahedroned," which has the charming feature of concealing a regular octahedron in the unfilled space in its center. Like 2-cubed, 2-tetrahedroned is a larger tetrahedron of doubled edge length. However, its numerical value, that is the count of its unit cells, is 4, not 8. Also on 2-triangled as a base, may be constructed "2-octahedroned," and "2-icosahedroned." The latter solid, which consists of 12 icosahedral unit cells, "overfills" the three-dimensional space by causing each of its unit cells to interpenetrate (Figure 3).

Finally, on the base of "2-pentagoned," one may construct "2-dodecahedroned," a dodecahedron whose edges are twice the length of the original, and which consists of 20 interpenetrating unit cells (Figure 4). These solid figures may be continued indefinitely, always producing a larger solid self-similar to the original unit cell.

I believe that atoms arranged at the vertices of the figure of n-dodecahedroned would answer to the requirements of a quasicrystal lattice which exhibits a dodecahedral crystal form, such as the AlFeCu and AlPdMn alloys first produced in 1988 and 1990. The lattice points of this model arrange themselves in decagonal patterns around a given center, as I elaborate below, just as is seen in diffraction studies of quasicrystals. Also corresponding to the evidence of diffraction images, the spacing of the n-dodecahedroned lattice in certain linear directions follows the golden section.

Hexagonal vs. Pentagonal

Modern crystallography originated with Johannes Kepler's studies of the "fitting together" (*congruentia* or *harmonia*) of figures in two and three dimensions. Of special importance to the development of crystallography was his study of the packing of spheres. In a single layer of spheres, pushed together in the most compact way, each sphere is touched by six others. This hexagonal theme is continued into the three-dimensional configurations of close-packed spheres.

As Kepler showed in his *Six Cornered Snowflake*, when 12 spheres are forced together around a central one (closely packed), the connection of the spherical centers forms a cuboctahedron, a solid

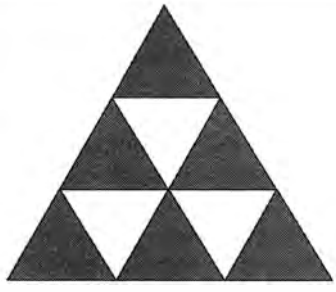


Figure 1
3-TRIANGLED
Note the triangular gaps in the tiling of the grey triangles which build 3-triangled.

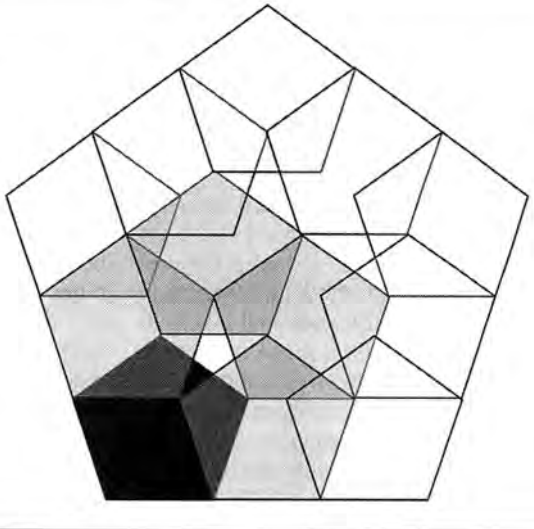


Figure 2
3-PENTAGONED
Five unit pentagons interpenetrate to form 2-pentagoned, and 12 to form 3-pentagoned.

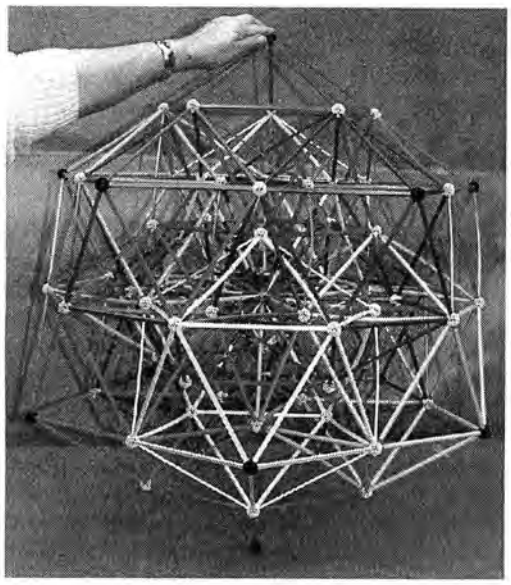


Figure 3
2-ICOSAHEDRONED
The large icosahedron envelops 12 interpenetrating unit icosahedra. Each face is 2-triangled.

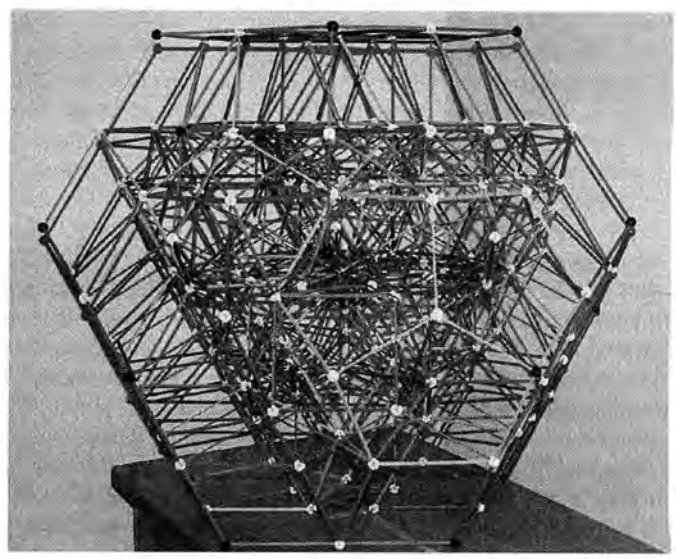


Figure 4
2-DODECAHEDRONED
2-dodecahedroned contains 20 interpenetrating unit dodecahedra. Each face is 2-pentagoned. (See color reproduction on back cover).

which may also be produced by the intersection of four circular hoops, each dividing the other into six parts (Figure 5). Hence the six-fold, or hexagonal symmetry. (The forms deriving from cube, octahedron, and tetrahedron are broadly considered as of hexagonal symmetry but of a lower class.)

Kepler wondered if an arrangement of that sort, at the microscopic level, might not be the reason for the ever-present hexagonal symmetry of snowflakes. He also noted that non-living things tended toward the hexagonal symmetry, while plants and animals often exhibited the pentagonal symmetry, and the associated golden ratio, or divine proportion, which is expressed in the ratio of edge length to diagonal on the face of a pentagonal dodecahedron.

His short work on the snowflake, written in a playful tone as a New Year's gift to his ducal sponsor, exposes his creative genius in a most compact way, and ranks among the most seminal pieces in modern science. Of special interest to crystallography, is his description of his discovery of a new solid, the rhombic triacontahedron, the shape exhibited by the first quasicrystals with clearly distinguishable grains grown in 1986.

What began as Kepler's musings on the snowflake was later followed up by many others into the modern developments of crystallography. Notable was the work of the Abbé Haüy in the late 18th Century, explaining the regular shapes and angles of crystals as a result of repetition of an integrant form; Mitscherlich through his chemical investigations of crystal isomorphism; Pasteur with his groundbreaking discovery of hemihedral crystals of mirror symmetry; von Federov, who created a table of 10,000 different crystals, allowing the identification of an unknown substance by measurement of its facial angles; and Max von Laue who demonstrated in 1913, by means of X-ray diffraction, that there were indeed tiny points in the crystal lattice, corresponding to what had, by then, been assumed to be the locations of atoms.

A consistent feature of all these studies was that the crystals were considered to be made up of units which touched each other at their surface boundaries. With the n-dodecahedroned construction, I am suggesting that a new kind of "fitting together" be considered, in which a periodic form of interpenetration of the structural units takes place.

In Kepler's early concepts, the structural units were individual spheres. Haüy in 1784 proposed that crystals were built up of little bricks, or parallelopipeds, of varying shape for each substance. That view reached a high stage of development in the early 19th Century when geometrical studies showed that only 32 types of crystal symmetry were possible. Then Frankenheim (1842) and Bravais (1848) established the concept of the unit cell, a way of representing the relationship of the lattice points to each other in the form of 14 different types of brick-like solids, a lattice point at each corner, which could be piled up to represent all possible crystal forms—or so it was thought.

It was at first supposed that the lattice points might correspond to the chemical molecules of the substance. But the development of X-ray crystallography tended to the view that the crystal was composed of individual atoms, and the lattice points of crystallographers became synonymous with atoms or ions. Crystals of compound substances came to be explained as interpenetrating combinations of the basic known space lattices. With the development of the electron theory, the glue that held the crystal together was thought to be the interaction of electrons, although metallic crystals posed a special problem. Thus, essentially forces emanating indi-

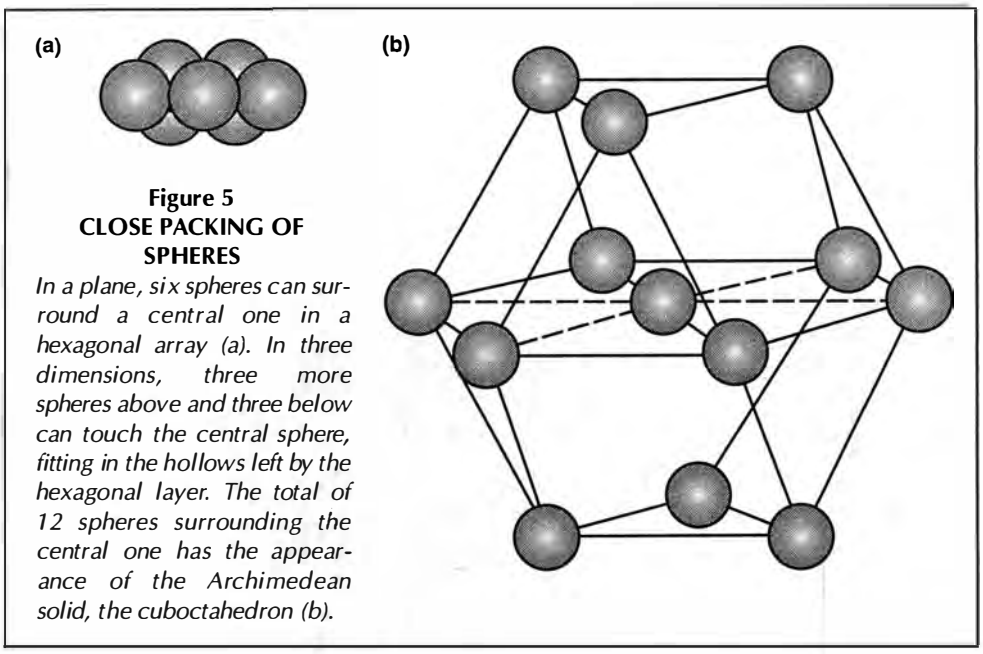


Figure 5
CLOSE PACKING OF SPHERES

In a plane, six spheres can surround a central one in a hexagonal array (a). In three dimensions, three more spheres above and three below can touch the central sphere, fitting in the hollows left by the hexagonal layer. The total of 12 spheres surrounding the central one has the appearance of the Archimedean solid, the cuboctahedron (b).

vidually from each point of the crystal seemed to hold the crystal together. If each atom acted according to its instincts, the job would be done.

But these views were challenged after 1984 with the discovery by Israeli metallurgist Dany Shechtman of metal alloys which showed the forbidden five-fold symmetry, and a quasiperiodic ordering of lattice points in their diffraction patterns. There seemed to be no way to imagine by the known rules of crystallography that such a structure could come together.

The Principle of Homogeneity

I believe I have shown in the n-dodecahedroned construction, a way of extending the so far accepted laws of crystallography to account for a crystal of five-fold symmetry. With one significant variation in the usually accepted axioms of crystallography, a regular unit cell, repeated in periodic fashion, can produce a dodecahedral or icosahedral crystal form. The required variation is, that instead of cells which fill space with no gaps, we must allow an interpenetration which produces an "overfilling" of the space.

I have spent some time trying to imagine how this variation might alter the relationship of one lattice point to another. Is it still possible to describe the structure as the result of the individual action of each constituent atom or ion, or is it necessary to suppose a sort of collective action or field determining the growth? If the quasicrystal is describable as the result of forces emanating from each individual atom, then geometrically each lattice point must be indistinguishable from the next; that is, every atom must have the remaining atoms arranged about in the same manner. This is known in crystallography as the principle of homogeneity.

In the n-dodecahedroned lattice, 30 edges protrude from each vertex in the 30 directions of the vertices of an icosidodecahedron. (The precut spheres of the Zome brand construction kits provide just enough positions for this arrangement.) In a model of 2-dodecahedroned, the central vertex at which 20 dodecahedral unit cells come together, will show these 30 directions. As the model is expanded, each vertex will show the same arrangement. As the icosidodecahedron may be produced by the intersection of 6 rings or hoops, each one dividing the other into 10 parts, one sees that there are 6 planes in which a decagon surrounds a central point.

However, as the n-dodecahedroned lattice grows, something new arises. Because of the overlap of cells, a vertex from an adjacent interpenetrating dodecahedral cell cuts the original edge in a golden section. Thus, around each vertex is a group of 30 nearer vertices coming from interpenetrating cells. However, closer inspection shows that each vertex is not the same. Because of the fact that the edges are cut in golden section, there seem to be vertices which are distant by the smaller part of the section, and others which are distant by the larger part, from the nearest neighboring vertex.

Thus the principle of homogeneity, requiring that every atom have the remaining atoms arranged about it in the same manner, is violated.

This conclusion, apparently consistent with some of the results of X-ray diffraction studies, requires more thorough geometric investigation. If true, it would seem to require that the quasicrystal cannot be conceived as resulting from uniform forces emanating from each atomic center. We might instead suppose that the functional unit of formation is the whole dodecahedron. We seem thus to return to the idea of the unit cell as a functional unit, rather than merely the descriptive unit it has become for modern crystallography.

However, it were then necessary to provide a reason why the dodecahedral cells assemble in the fashion that they do. The simplest explanation would seem to be that the whole crystal seeks a dodecahedral form, and finds it in the only way which geometry permits such a self-similar growth.

Such a hypothesis would be repugnant to the extreme mechanist or reductionist, who seeks to explain all events of nature from presumed elementary particles and the forces of attraction or repulsion between them. Yet, we have not found a clearer one. We hope to discuss this aspect of the matter further in future communications. We have also not addressed here the implications of the appearance of the dodecahedral form for our studies of the nuclear model of Prof. Robert J. Moon. The appearance of the elements aluminum (Z = 13), manganese or iron (Z = 25,26) and palladium (Z = 46) is most suggestive in this respect.

Notes

1. Translation by Ivor Thomas, *Selections Illustrating the History of Greek Mathematics*, (Cambridge, Mass.: Harvard University Press, 1993) p. 515 (from Diophantus, *On Polygonal Numbers* [5], Dioph. ed. Tannery i. 470. 27-472. 4).

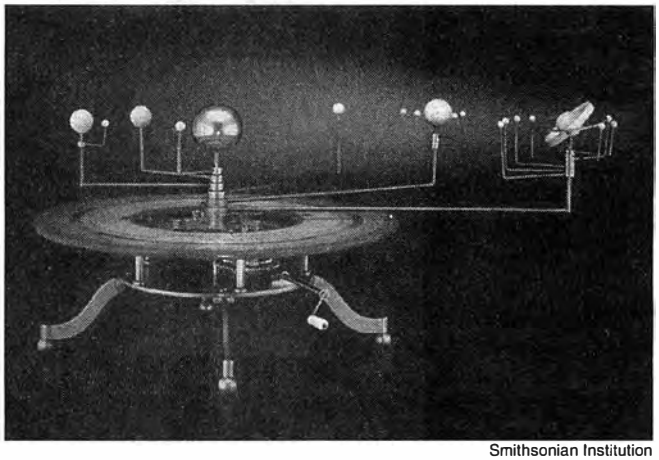
FROM KEPLER TO LAROUCHE

Von Neumann Was Wrong: The Solar System Teaches Us Economics

by Michelle Lerner

SCIENCE and the LaRouche Youth Movement

The greatest challenge the youth of today face, is that of the mastery of the ideas that would enable the generation to surpass Lyndon LaRouche, the greatest genius alive. Not only is this a formidable task, but it is a necessary one. The destruction of the global economy has given young people a strong reason to believe that they are a "no future" generation. LaRouche, who is an octogenarian, organized the LaRouche Youth Movement with this intention: Create a generation of leadership ready to overcome what otherwise would be a catastrophe.

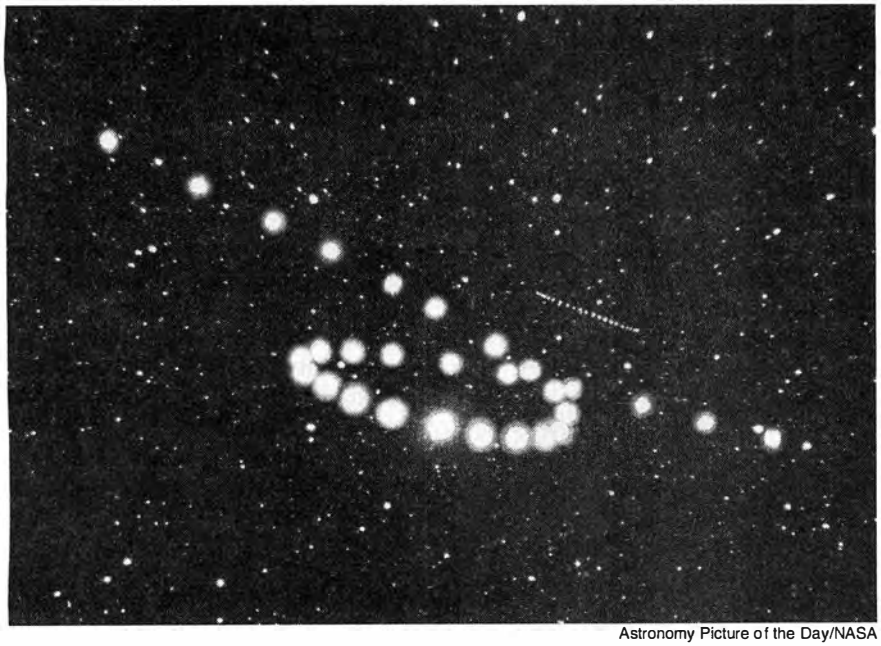


Smithsonian Institution

An orrery, or mechanical solar system. Newton's universe is a giant clockwork in need of occasional winding by the Creator, in contrast to Kepler's dynamic view of the universe and planetary action.

We need a future. But in order to obtain one, we first need to understand economics as LaRouche does! In order to solve a problem, you must first be able to diagnose it.

To gain an insight into what has happened to the global economy, it is useful to know that the greatest fraud of 20th Century economics was perpetrated by two of Bertrand Russell's stooges, Norbert Wiener and John von Neumann, whose widely accepted doctrines of "information" and "game" theories have been critical in the destruction of the minds of so many of our citizens. These are precisely the doctrines that LaRouche saw, in his youth, as a threat to civilization.



Astronomy Picture of the Day/NASA

The retrograde motion of Mars, shown here in a time-lapse photo, is the universe that you don't see, casting a shadow on the one that you do see.

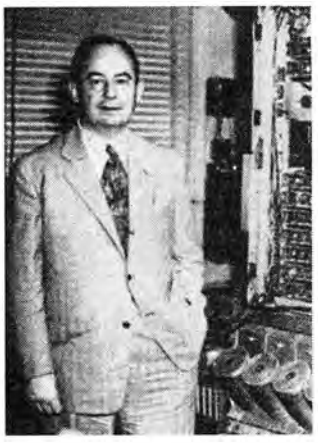
The 'Theory'

First, pose the question to yourself: What is economics? One might say the distribution of goods and services. In that case, money would seem to be a very important means of exchange. But, how do you determine prices and organize an economic system, which includes a number of individuals, all interacting with one another? John von Neumann and Oskar Morgenstern wrote, in their very long book *Theory of Games and Economic Behavior:*

> The subject matter of economic theory is the very complicated mechanism of prices and production, and of gaining and spending of incomes. . . . We shall therefore assume that the aim of all participants in the economic system, consumers as well as entrepreneurs, is money, or equivalently a single monetary commodity. This is supposed to be unrestrictedly divisible and substitutable, freely transferable and identical, even in the quantitative sense, with whatever "satisfaction" or "utility" is desired by each participant.

Bertrand Russell (1872-1970)

Norbert Wiener (1894-1964)



John von Neumann (1903-1957)

Isaac Newton (1642-1727)

The book continues on with a look at how this works with a single individual and limited resources, the slightly more complex case of two individuals, the even more complex case of three individuals, and so on. So, we have a model of a universe composed of individuals and objects. The individuals interact with these objects so as to maximize their pleasure and minimize their pain. Accordingly, "the individual who attempts to obtain these respective maxima is also said to act 'rationally.' " Anyone not fitting this description behaves "irrationally," and therefore complicates this whole scheme of economics all the more.

Norbert Wiener, closely associated with von Neumann and Morgenstern, further elaborated the way in which we interact with the surrounding universe of objects, in *The Human Use of Human Beings: Cybernetics and Society:*

> Man is immersed in a world which he perceives through his sense organs. Information that he receives is co-ordinated through his brain and nervous system until, after the proper process of storage, collation, and selection, it emerges through effector organs, generally his muscles.

Much of this was already postulated by others, like Francis Bacon, René Descartes, and Isaac Newton. As implicit in Newton's "*hypothesis non fingo*" [I don't make hypotheses], the idea of collection of sensory data and facts as the foundation of scientific work was not new. Wiener and von Neumann, however, took that method a step further.

To determine how to quantify an economic process, Von Neumann points out in *Theory of Games and Economic Behavior,* that the development of mathematics has been extremely successful in science, particularly the application of the infinitesimal calculus to physics. And therefore, according to him, the method by which it had been developed in science can be applied here to develop a mathematics for economy. But, holding up that development, has been that:

> Our knowledge of the relevant facts of economics is incomparably smaller than that commanded in physics at the time when the mathematics of that subject was achieved. Indeed, the decisive break which came in physics in the seventeenth century, specifically in the field of mechanics, was possible only because of previous developments in astronomy. It was backed by several millennia of systematic, scientific, astronomical observation, culminating in an observer of unparalleled caliber, Tycho de Brahe. *Nothing of this sort has occurred in economic science. It would have been absurd in physics to expect Kepler and Newton without Tycho,—and there is no reason to hope for an easier development in economics* [emphasis added].

Now, one might be compelled to make the argument that von Neumann is just simply stating facts. But, don't be fooled! The acceptance of facts is precisely the hoax that these sophists would have you fall for! It shouldn't be surprising that these are students of the same Bertrand Russell who declared, in the *Impact of Science on Society,* that " 'purpose' is a concept which is scientifically useless." Russell argued, along with his students, that the only alternative to an absolutely chaotic universe, in which the will to do good is only a futile effort, is for the planet to be managed by a socialist world government. This type of economic system would, of course, be organized by a government that had total control over raw materials, as well as rigid population control methods. How else would we keep things from getting out of hand?

Intention in the Universe?

Fortunately, as LaRouche frequently makes the point, the universe does not operate the way this pack of nuts would have you believe. And ironically, in point of "fact," physics, the development of the infinitesimal calculus (which von Neumann attributes to "Newton's creation of a rational discipline of mechanics"), and ultimately the science of economics, whether physical or political, developed in a completely different way. As a testimony to that "fact," Johannes Kepler, who discovered a principle of universal gravitation, makes the point about science in the beginning of the *New Astronomy:*

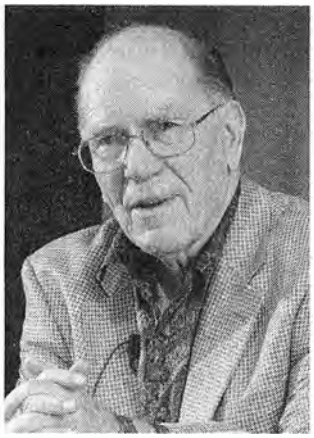
> The testimony of the ages confirms that the motions of the planets are orbicular. It is an immediate presumption of reason, reflected in experience, that their gyrations are

Johannes Kepler (1571-1630)

Nicholas of Cusa (1401-1464)

Gottfried Leibniz (1646-1716)

Vladimir Vernadsky (1863-1945)



Stuart Lewis/EIRNS

Lyndon LaRouche

perfect circles. For among figures it is circles, and among bodies the heavens, that are considered the most perfect. *However, when experience is seen to teach something different to those who pay careful attention,* namely, that the planets deviate from a simple circular path, *it gives rise to a powerful sense of wonder, which at length drives men to look into causes.* It is just this from which astronomy arose among men. Astronomy's aim is considered to be to show why the stars' motions appear to be irregular on Earth, despite their being exceedingly well ordered in heaven, and to investigate the circles wherein the stars may be moved, that their positions and appearances at any given time may thereby be predicted [emphasis added].

Go back to ancient man. How would he actually come to know about the world surrounding himself? Indeed, mere information and data collection leave us at a loss. Watching the nighttime sky, it appears that you are the center of the universe and everything else is spinning around you. Do you see reality? You don't really even see what is overhead at the moment that you are looking there. You see what appears to be motion on the inside of a giant sphere, motion that occurred long ago. This seems to work fine, until you run into the paradox of a motion that does not seem to fit into this spherical view of the world around you. The universe that you *don't* see is casting a shadow onto the one that you *do* see.

With the retrograde motion of Mars, there is an ambiguity; something doesn't seem quite right. Again, how do you come to find out what is really going on up there? The challenge then, is coming to know what is causing the effects that we call sense perception, in this case, the ambiguity caused by the motion traced by Mars. The struggle over this paradox of sense perception, which is unique to, and probably as old as, the human race itself, is the fundamental starting point for any competent science, especially a science of economics.

According to Lyndon LaRouche, economies are not, and can never be, fixed systems. They are dynamically changing processes, which either improve or collapse. LaRouche, the most successful economist alive, put forward the LaRouche-Riemann method, which can only be understood by getting at what really made someone like Kepler possible. (Another irony, however, is that the better you understand LaRouche, the deeper an understanding you can develop of Kepler.)

What Made Kepler Possible?

Kepler inherited an historic fight, which he advanced upon. This fight has its roots in the epistemological battle surrounding a concept of man, and the ability of man to know the universe of which he is a dynamic part. In the introduction to the fifth book of the *Harmonice Mundi,* Kepler says,

> . . .[I]t is my pleasure to taunt mortal men with the candid acknowledgement that I am stealing the golden vessels of the Egyptians to build a tabernacle to my God from them, far, far away from the boundaries of Egypt. If you forgive me, I shall rejoice; if you are enraged with me I shall bear it. See, I cast the die, and I write the book. Whether it is to be read by the people of the present or of the future makes no difference: let it await its reader a hundred years, if God Himself has stood ready for six thousand years for one to study him.

Being a student of Plato, Kepler's reference to Egypt should come as no surprise. Plato opens his *Timaeus* dialogue, a work that is crucial for Kepler, with an account, passed down to Timaeus by his great-grandfather, of the way that Solon of Athens came to know of the true Egyptian origins of the city. The *Timaeus* is the continuation of a discussion from the day before, which Plato relates to us in his *Republic.* The significance of this for our purposes here, is that this philosophical fight over the nature of man is

the basis for the political fight developed in Plato's *Republic* and transmitted over centuries of European history to the shores of North America.[1] The same fight for which Socrates, Plato's teacher, was killed, made the United States Constitution possible. The intention of those such as Russell, Wiener, and von Neumann, who would seek world empire as opposed to a community of sovereign nation-states, is to destroy that aspect of the mind, which made Kepler and many others possible, for the purpose of destroying the ability of the individual to play a functional role in the development of the institution of the nation-state, and have a part in shaping his own destiny. But then, what is that quality of mind which was, and remains, so threatening to this crowd?

Creativity or 'Rational Behavior'?

In his *Republic,* Plato, a student of the methods of the ancient Egyptians and their science of astrophysics, otherwise known as sphaerics, describes sense perception as shadows on a cave wall, not reality. Johannes Kepler, the genius who discovered the principles of universal gravitation as a student of Plato, did not arrive at his discovery by staring at the sky or at numbers, but in a quite different way.

Von Neumann presents "rational behavior" as a drive of the individual to maximize his utility. In contrast, Kepler, in his writings, elaborates on the way in which the power of creative genius can actually involve what Socrates, who refers to himself as a midwife of ideas, might call labor pains. So the question is now twofold: We are not only investigating what moves the planets in their orbits, but also what moves human minds. In other words, what is the relationship of the mind to the universe, of which it is a part?

Norbert Wiener proposes in his *Cybernetics:*

> It is my thesis that the physical functioning of the living individual and the operation of some of the newer communications machines are precisely parallel in their analogous attempts to control entropy through feedback.

And that:

> Sooner or later we shall die, and it is highly probable that the whole universe around us shall die that heat death, in which the world shall be reduced to one vast temperature equilibrium in which nothing really new ever happens. There will be nothing left but a drab uniformity out of which we can expect only minor and insignificant local fluctuations . . . it may be a long time yet before our civilization and our human race perish, though perish they will even as all of us are born to die.

As emphasized earlier, Wiener and von Neumann were devout students of Bertrand Russell, in whose scheme of things the world is better organized by a socialist world government. That way, by implementing population control methods, such as genocide and warfare, and controlling the distribution of "limited resources," "survivors can procreate freely without making the world too full" (Russell, *Impact of Science on Society*), and therefore, we prolong the period before the arrival of our doomed fate.

However, if one takes the time to really examine the works of such thinkers as Kepler, Leibniz, Vernadsky, and LaRouche, one finds that all this talk really reduces to nothing more than mere sophistry. This sophistry of entropy was already refuted, as Russell, Wiener, and von Neumann well knew, by Gottfried Leibniz's refutation of Isaac Newton's representation of the universe as a giant clock (which needed to be wound up from time to time by the Creator). Leibniz, another follower of Kepler, had done this in written correspondence with Samuel Clarke, a defender of Newton's theories.

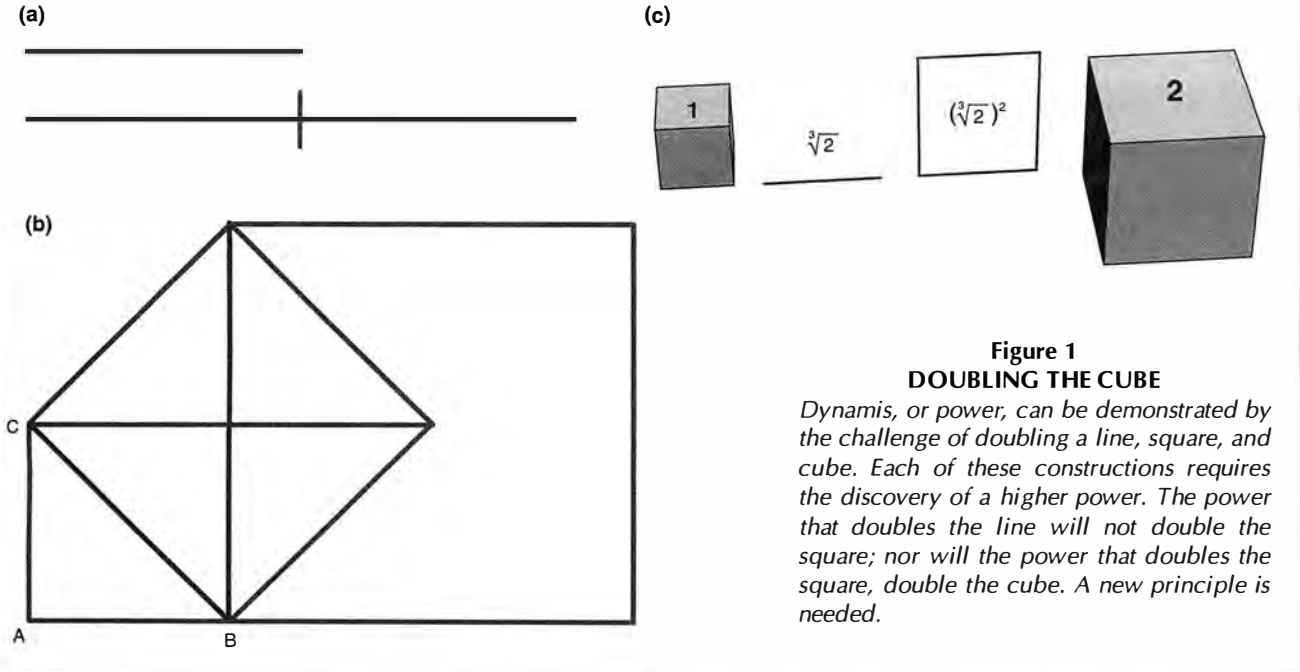


Figure 1
DOUBLING THE CUBE

Dynamis, or power, can be demonstrated by the challenge of doubling a line, square, and cube. Each of these constructions requires the discovery of a higher power. The power that doubles the line will not double the square; nor will the power that doubles the square, double the cube. A new principle is needed.

Leibniz's refutation of the Second Law of Thermodynamics, or entropy, reintroduced the Pythagorean method to a population of Europe which had been devastated by decades of religious warfare of the type that Kepler himself had warned about. The issue then was the same as now, as well as in Plato's time. Kepler, in warning the Austrians about the type of warfare that could erupt when the population neglects sciences and geometry, made reference to an ancient Greek problem known as the "Delian problem" (Figure 1). As Plato had pointed out to the Delians long ago, the inability of Delians to solve the problem of doubling the cube was indicative of the population's inability to solve problems in general, especially economic problems such as a plague. The issue of doubling the line, square, and cube, is not one of objects, but of powers, or in Greek *dynamis.* This "Delian problem" has proven to be a problem for the American population today.

The issue that Leibniz raises in his refutations of Descartes's mechanical and Newton's "clock-winder" universes, is precisely this issue of powers. Action in the universe is not determined by objects bouncing around and bumping into one another in a vacuum. As Leibniz's catenary-cued infinitesimal calculus demonstrates,[2] action in the universe is determined by principles of change, or powers. Leibniz called this action *dynamic.* LaRouche has emphasized that this breakthrough by Leibniz, on a science of dynamics, is the basis for understanding the fundamentals of a science of physical economy, just as the idea was echoed by Alexander Hamilton's notion of "productive powers of labor." This ability of the human mind to attain these powers, through discoveries prompted by paradoxes of the senses, or otherwise, increases our influence over the universe.

SCIENCE and the LaRouche Youth Movement

Kepler Measures Change!

Kepler's discovery of what causes the motions in the heavens, implicitly proves that this idea of entropy is not only absurd, but anti-scientific. The very possibility of making a real discovery is enough to prove that. Having developed in his mind the methods of the ancient Egyptians, Pythagoreans, and Platonic thinkers, Kepler came up with his first hypothesis of planetary motion, largely from their work, rather than from the measurement of data. His first hypothesis involved an arrangement of the Platonic solids inscribed and circumscribed by neighboring spheres (Figure 2). The Platonic solids are given their name because they were first described by Plato, in the *Timaeus.* These solids are the dodecahedron, icosahedron, octahedron (which is the model for the pyramids of Giza), tetrahedron, and cube. They represent the tiling, or equal divisions of a sphere. In "fact," to test his hypothesis, he used the measurements of Copernicus, and not Tycho Brahe, with amazing results. In the *Mysterium Cosmographicum,* he presents two tables (see p. 15).

As you can see, the numbers are not perfect, but they are extremely revealing. So now what? There is still something missing here. The first hypothesis was good, but not good enough. Kepler's real breakthrough came from the paradox of the retrograde motion of Mars, mentioned earlier. It is true that to resolve this Kepler used the best observations, which came from Brahe; however, the observations did not produce the hypothesis. Otherwise, Brahe could have solved it himself, which he could not. No, there was something else that Kepler had to address, in his own thinking as well as that of others.

Aristotle, the enemy of Plato, argued that perfection is evidenced in that which changes the least, which in shapes is the circle. This assumption, that the heavens must be moving in perfect circles, was the largest impediment to the development of this science. Once Kepler was able to free himself from this bondage, he discovered a remarkable principle behind the planetary orbits. Ironically, what he had known from the very beginning was more true than he had realized.

In the original dedication to the *Mys-*

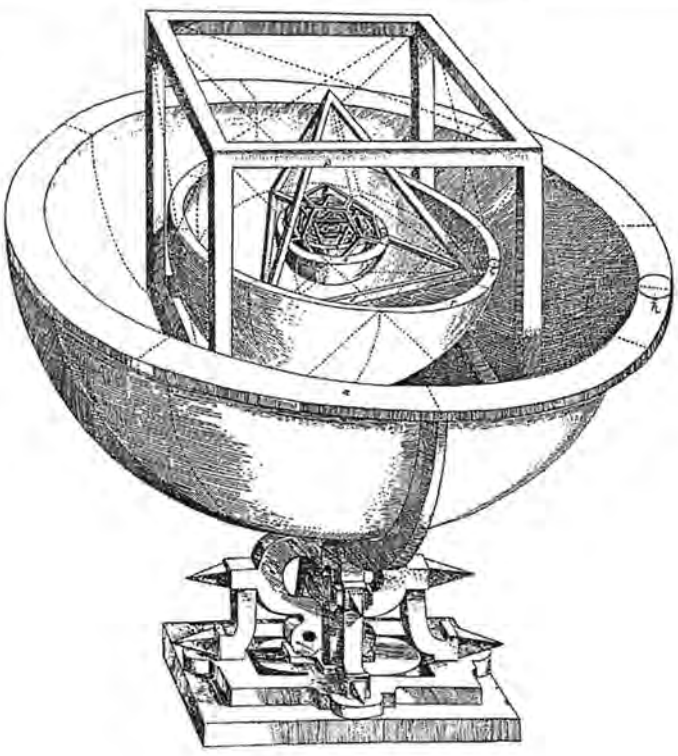


Figure 2
KEPLER'S SOLAR SYSTEM
Kepler's first hypothesis of planetary orbits was a nested arrangement of the five Platonic solids with their inscribing and circumscribing spheres.

terium Cosmographicum, Kepler wrote:

> God, like one of our own architects, approached the task of constructing the universe with order and pattern, and laid out the individual parts accordingly, as if it were not art which imitated Nature, but God himself had looked to the mode of building of man who was to be.

Kepler discovered that the most perfect pathway for the planets to travel is that which changes the *most,* elliptical orbits. Furthermore, the principles that make choral polyphony possible are inherent in the ordering of the solar system. This should come as a shock to anyone who has studied chemistry, biology, or physics in any modern university. Neither the Second Law of Thermodynamics, nor Darwinian evolution, are compatible with Kepler's discovery. Therefore, in order to develop a working conception of economic activity—the science of human interaction with the universe as well as with other human beings—we must adopt a new approach to measuring change in the universe.

KEPLER'S PLANETARY CALCULATIONS FROM *MYSTERIUM COSMOGRAPHICUM*

Table 1

in	length of edge	radius of circle circumscribing a face	radius of inscribed sphere
the Cube	is 1155	is 816½	is 577
Pyramid	1633	943	333
Dodecahedron	714	607	795
Icosahedron	1051	607	795
Octahedron	1414	816½	577 707 in case of circle inscribed in square of octahedron. Note this.

Table 2

								Bk. V of Copernicus
If lowest point of	Saturn	is 1,000 highest point should be	of	Jupiter	577	But according to Copernicus it is	635	Ch. 9
	Jupiter			Mars	333		333	Ch. 14
	Mars			Earth	795		757	Ch. 19
	Earth			Venus	795		794	Ch. 21 & 22
	Venus			Mercury	577 or 707		723	Ch. 27

Beginning with the model of inscribed and circumscribed Platonic solids, the lengths of the respective radial lines are shown in Table 1. The comparison of these lengths with the actual distances between planetary orbits, as measured by Copernicus, is shown in Table 2. Both tables are reproduced from Kepler's Mysterium Cosmographicum.

A Dynamic View of Economics

At an international conference held in Berlin, in June 2005 by the Schiller Institute, LaRouche said that, "you define currencies by a tendency toward *equality of power of reproduction.* In other words, a Leibnizian concept, a *dynamic* concept; a Vernadskian concept, in the sense that you no longer use the Cartesian method of accounting." [See "Dialogue with LaRouche: How Do You Determine a Currency's Value?," *EIR,* July 8, 2005].

LaRouche often references Vladimir Vernadsky, who in the tradition of Mendeleyev and Pasteur, approached this challenge by creating a new field of science called biogeochemistry. According to this science, the universe is composed of at least three distinct phase-spaces, each one more powerful, with a greater potential for change, than the one preceding it. Kepler had already anticipated such a composition of the universe, which is implicit in his discovery of gravitation and explicit in his essay "On the Six-cornered Snowflake." The first of these three phase-spaces is the abiotic, nonliving domain; the second is the biotic, living domain of the Biosphere; the third is the noetic, cognitive domain of the Noösphere. Look back at Kepler from this standpoint.

The abiotic domain, the non-living, non-reproducing part of the planet, changes over extremely long periods of time. You see this reflected in the minimal amount of change that takes place on other planets, where life is not present. The Biosphere changes the Earth, particularly its chemical composition, at a much more rapid pace. This change occurs through the interaction of living substance with the nonliving, through processes such as metabolism and respiration. This process becomes more intense as more of the substance of the Earth becomes living through reproduction. Vernadsky makes clear that life has a tendency to spread everywhere it can, as quickly as it can.

Prior to Vernadsky, Leonardo of Pisa (Fibonacci) discovered that the growth of populations converges upon the Golden Mean (Divine Proportion). This work was continued throughout the Renaissance by Leonardo Da Vinci and Luca Pacioli. This characteristic is not only a characteristic of populations, but of individuals as well. In his snowflake paper, Kepler describes the difference between the living and nonliving in terms of a geometric difference. The Divine Proportion, which is found throughout living processes, is representative of a pentagonal geometry. The only Platonic solid composed of pentagons happens to be the dodecahedron, which is also the only one which encompasses the other four within it. According to the Keplerian model based on these solids, the Earth's orbit is surrounded on the outside by the dodecahedron, and on the inside by its dual, the icosahedron. Earth is the only planet that we know of that has been able to sustain highly evolved life forms.

Nonliving processes, as Kepler noted, are characterized by a hexagonal geometry, such as is represented in snowflakes and soap bubbles. The Golden Mean is not contained in this geometry, but is found only in the high-

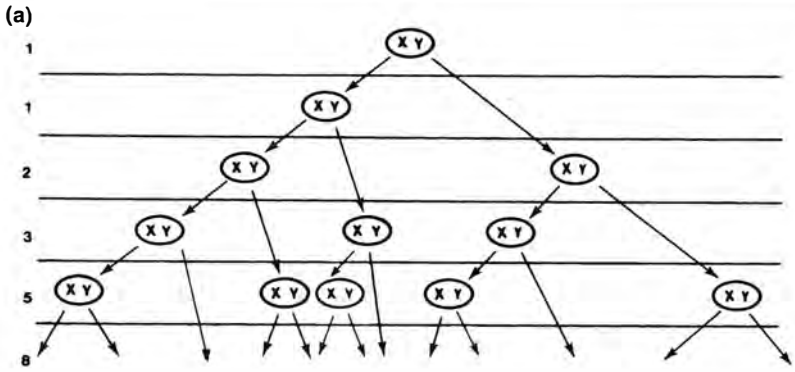


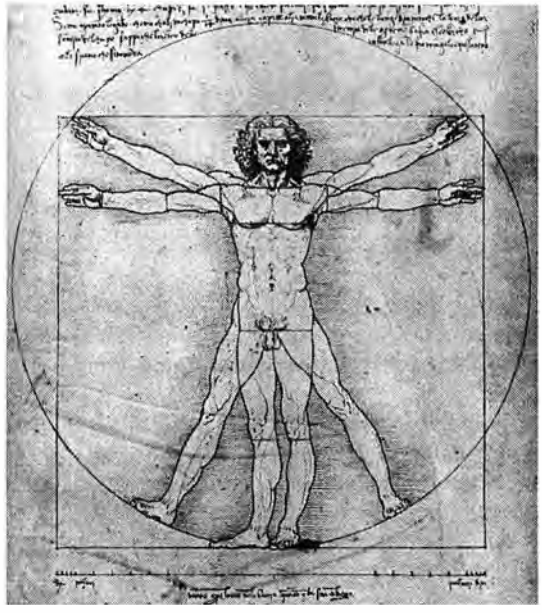
Figure 3
POPULATION GROWTH AND THE GOLDEN SECTION

The Divine Proportion is evidence of the principle of life as the ordering principle of the Biosphere as a whole.

In population growth in accordance with the Fibonacci series (a), each number is the sum of the two preceding numbers. In this simple case, the assumption is made that every pair (xy) lives for two generations and produces one pair of young during each generation. Each of these pairs lives for two generations and dies after producing the second pair of young. If, additionally, each pair of young consists of a male and female animal, which again produce two generations of young, then the growth of this animal population corresponds to the Fibonacci series.

Leonardo's famous illustration of the Divine Proportion and man, is shown in (b).

(b)



Source: *So You Wish to Learn All About Economics?* by Lyndon H. LaRouche, Jr. (New York: New Benjamin Franklin House Publishing Co., Inc., 1984), p. 7.

er pentagonal one.

But, as the point is made by LaRouche, when it comes to human reproduction, there is even a higher order of principles involved, which again directly come into conflict with the "information" theorists. In order to reproduce a generation of human beings, what is involved, in addition to supplying the physical necessities to individuals, is the replication of, not only the discoveries that made their existence possible, but also the methods that make such discoveries possible.

LaRouche identifies two classes of principles that make up this process. These are the principles associated with making the discoveries and the principles associated with communicating those ideas; in other words, universal physical principles and social, or artistic principles. Kepler's approach to, and understanding of, the solar system sheds light on both.

Kepler's method of generating the higher hypotheses of what lies beyond the senses is exemplary of the process of creative discovery, as opposed to von Neumann's whacky notion of "rationality" and "information theory." The mastery of such principles gives to man new powers, the powers expressed and nurtured by Alexander Hamilton's application of a science of physical economy, which lay the basis for new technologies, raising the standard of living in the population, and defining new potentials that were not possible before. These powers, achieved through creative acts, which cannot be expressed as willful actions in any other species of life, increase the ability of mankind to populate the planet without fear of running out of "limited" resources. It makes possible the ability to assume our proper role throughout the entire solar system. As these powers become integrated into the economy, the artifacts of this process form the Noösphere, the interaction of man's mind with the biotic and abiotic domains, which he uniquely can change. But, in order to continue this process of change such that the economy of a nation is always above breakeven level—that is, that the physical investment is exceeded by the physical profit—there is a necessity for one more thing. The ability to do this, to increase the productive power of a national economy through breakthroughs in science, must be communicated among individuals in a given population of a nation, as well as to individuals from among different nations and cultures, in present and future generations.

Freedom Expressed Through Beauty

The ideas that Kepler drew from were transmitted over centuries from the ancient Greeks and Egyptians. A heightened power of communication, as mentioned earlier, was also transmitted to Bach, through Kepler's further development of another ancient Greek paradox, known as the Pythagorean Comma. Kepler discovered that the musical harmonies are embedded in the ordering of the solar system. He discussed these in terms of human voice species. This is one of the most amazing aspects of his discovery. Bach developed the science of musical composition, a science of social principles, from the potential that is made possible in choral polyphony. This is a uniquely human process.

Wiener and von Neumann would have you think that all you can know is information or facts, not principles, and that language is just the transmittal of these facts and data. Bach, advancing the work of Kepler, makes music a truly universal language, in a way that is truly beautiful, by the development of his well-tempered system of tuning, based on the universal physical characteristics of the human singing voice, a noetically and biologically determined feature. The usefulness of a scientist is lost if the breakthroughs that he or she makes are never communicated. The challenge one faces is to communicate a totally new idea that has never been defined, and where the necessary words don't even exist. In music, as Bach develops it, the idea is not in the notes, but "between" them, in the passing of an idea from one voice to another.

Understanding how this process works in music gives us a forum to investigate how the communication of ideas works in general. What LaRouche discovered on this point is that the task of an artist in this context is to bring the audience through precisely the process that went on in the mind of the original discoverer. On the question of the determination of pricing, this too must be taken into account. LaRouche raises the question:

> Dwell briefly on the kinds of conceptual tasks we must face in asking ourselves what the proper level of income of households must become. For example: What is the cultural level we must sustain within the household and the communities within which the household exists as an organic part of a dynamic system? In other words, what is the level of cultural development which that standard of physical income in that community must reach? ["LaRouche Comments on Professor Hankel and Himself," *EIR,* Sept. 2, 2005]

And, here too, you find the true motivation of fighting with paradoxes: The fruits of that labor improve mankind. Your life, which in the long scheme of things seems but a single moment, can have that type of eternal effect by

Stuart Lewis/EIRNS

The author at a rally on Capitol Hill in November.

accessing this power of human creativity that forms the basis of a true science of economics.

Therein lies the only functional approach to developing a "mathematics" for the science of economy. We must measure the increase in the power of mankind to change the universe. The increase in Potential Relative Population-Density of a population is an effect of its increasing mastery of these principles. The ultimate change to measure is the change in the rate at which a population is generating new discoveries. That is the basis for the LaRouche-Riemann method. It is this power to change the universe that makes the human species truly free. That is why we are continuing this fight today, which we can trace through history. This is the fight for the defense of the principle of the General Welfare, as stated in the preamble to the U.S. Constitution, and the pursuit of Leibniz's notion of "happiness" stated in the Declaration of Independence. It is the fight for sovereign nation-states, as developed through a lawful historical process shaped around the development of language cultures.

This is the fight that we must win today. And therefore, unless we fail to meet the requirements of this crisis, the universe cannot possibly be entropic. It is the task, especially of the youth of today, to see to it that we do have the future that we so desperately need. And the only way to do this, is by becoming a universal, historical genius yourself!

Notes

1. The transmission of the ideas of Plato to the shores of North America was coordinated mainly through the figure of Cardinal Nicholas of Cusa, by way of the Renaissance, which was launched as a project to revive the ideas of the nation-state, with classical outlook of art and science, out of the midst of a Dark Age. Cusa's *De Docta Ignorantia* was the reintroduction to science of the Platonic idea, expressed by Socrates in the *Apology,* that wisdom is the search for ever higher hypotheses, through the method of seeking out paradoxes. These ideas formed the basis for the organizing of the Council of Florence, and the development of the idea of the modern sovereign nation-state.
2. The development of the infinitesimal calculus by Leibniz occurred as a response to the prompting of Kepler for a solution to paradoxes he couldn't solve. The common association of the discovery of the calculus to "Newton's mechanics" is a further expression of the political fight waged for the sake of a true Republic associated with this principle of creativity. Sir Isaac Newton, as head of the Royal Society in England, presided over the supposed controversy that broke out over who discovered the calculus, when it was clear that Leibniz's influence over certain factions in the court was becoming a threat to those who enjoyed the prospects of empire. For similar reasons, Russell and his pack of wild-eyed "information" theorists, associated with Russell, chose Leibniz, explicitly, as a subject for attack.

   The association of gravity with Newton can only be understood from a similar standpoint. Kepler preceded his investigation by looking into the intention expressed by the universe, whereas Newton proclaimed that that intention was unknowable. Russell's evil shines through with his proclamation that the idea of intention was useless. According to Newton, the most you could really do is come up with a description, such as the formula $F=GM_1M_2/D^2$. Therefore, it is appropriate to say that, by accepting these historical frauds, science thus becomes "Newtered."

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Vernadsky and Dirichlet's Principle

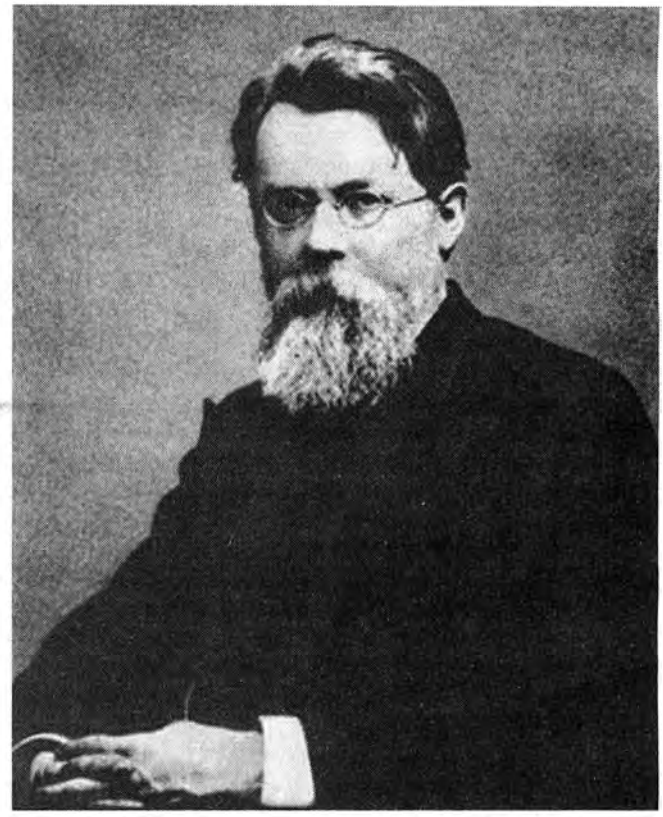
by Lyndon H. LaRouche, Jr.
May 18, 2005

The following is prompted by an examination of an implicitly accredited English translation of V.I. Vernadsky's 1935 On Some Fundamental Problems of Biogeochemistry, *secured through the Columbia University files contributed by V.I. Vernadsky's son, Professor George Vernadsky, New Haven, Conn., U.S.A.*

It is an often demonstrated fact of recent generations of European history, that certain victims of their classroom studies of Classical Greek, would have never understood any crucial concept of Plato's work, including the significance of the English term *Noëtic* as adopted from Academician V.I. Vernadsky's definition of the *Noösphere*.[1] The common source of the errors of all varieties of such failed former students of classroom Greek, and of many more others, still today, has been their disposition to look up definitions in dictionaries or by quoting so-called authorities, *rather than actually experiencing the relevant conception by replicating the original author's presentation of the process of generating the relevant discovery, as Vernadsky himself illustrated this method for acquiring knowledge of fundamental physical principles in the 1935 writing to which I refer here.*

Such has been my experience of most of the putatively learned and other failed modern commentators on the argument presented by Vernadsky, or also by others on related subject matters.

Indeed, most of the crucial conceptions of valid science in globally extended European civilization today, are to be traced from their implied origin in the pre-Aristotelean Classical Greek, as from Thales and the Pythagoreans through the works of Plato. The conceptions of *Biosphere* and *Noösphere* developed by Academician Vernadsky, are a case in point. These conceptions, which Vernadsky associated with the Classical Greek tradition, could not be adequately understood except in those historical terms of reference to Plato's actually intended, non-reductionist usage of the Classical Greek for stating principles of discovery illustrated in the 1935 paper considered here.



Vladimir I. Vernadsky (1863-1945)

What Plato actually refers to by such relevant terms, is to be known, not by reading a glossary, but by experiencing the actual act of discovery which solves the puzzle which Plato's argument presents in locations such as his pro-Heraclitus, *Parmenides* dialogue; only if the reader of that dialogue were a pedant, or a pompous fool such as G.W.F. Hegel, ignorant of the ABCs of the creative experience, would he have ever contested the authenticity of Plato's authorship of that dialogue.

The same point is illustrated by the appalling thick-headedness of Lagrange's attempted public refutation of that attack on his folly which had been delivered in Carl F. Gauss's 1799 dis-

1. For example, the contrary meanings associated with Plato and Aristotle, respectively.

sertation. The point is also illustrated by the standard act of classroom stupidity imitated by those literally millions of victims, who, in the course of times past, have swallowed arch-reductionist Augustin Cauchy's epistemologically childish "limit theorem."

Over the decades since the fact of the existence of V.I. Vernadsky's work first became known to me, near the close of the 1940s, I, looking as if out of the corner of my eye, had overview which was compatible, in principle, with certain discoveries which I had experienced during the initial phases of development of my own Leibnizian notion of physical economy as such.[2]

As Vernadsky defines the guidelines for a biogeochemical investigation of the boundaries separating the biosphere categorically from the abiotic domain, I had, as I explain below, developed my own, somewhat parallel approach to this view,

"The characteristics of the Biosphere, as Vernadsky . . . defined it, and Noösphere, as I define physical economies as wholes are analogous. Everything to which I have referred on this account, in excerpting Vernadsky's paper, has a parallel in my methods of a science of physical economy."

NASA

Vernadsky and LaRouche both distinguish between the Noösphere and the Biosphere. Here, an astronaut explores a large rock during a 1975 Moon landing.

come slowly to recognize that his most celebrated contributions had a certain potential relevance to my own independent discoveries in the field of a science of physical economy. That gradual recognition began more than fifty years ago, in the course of the continuing initial development of my own principled contributions. So, over decades, as more of his work came, as if piece by piece, gradually to my attention, I had come to recognize that he had already offered an that in work in which I, working from my standpoint as an admirer of Leibniz, subsumed the principled distinctions separating the principle of human scientific creativity from both animal and abiotic modes of behavior. However, until some work which my association did during the mid-1970s, I made no significant effort to incorporate the Vernadsky legacy directly into our work on the principles of physical economy. Even those efforts of the 1970s touched Vernadsky's work in a

2. For those not yet familiar with these facts, an actually scientific conception of economic processes was originally discovered, and developed, as a science of physical economy, as a branch of physical science, a science needed to replace and supersede the then pre-existing modern doctrines of what was known as cameralism. On the record, this development was done exclusively by Gottfried Leibniz during the interval 1671-1716. It was the influence of Leibniz's discoveries which informed the crucial features of the development of that American System of political-economy which latter has been the chief rival and adversary of the British system, worldwide, ever since. My own original discoveries, as a follower of Leibniz in this field, were developed by me, during 1948 and later, in continuing reaction against the radical reductionist follies of Norbert Wiener's argument for "information theory," in his 1948 *Cybernetics*. Over that interval of these original discoveries in the field of physical economy, 1948-1953, my adversarial targets had included the relevant work, on the founding of what became known as the "ivory tower" school of mathematical economics, of Bertrand Russell follower Wiener's co-thinker John von Neumann, as illustrated by von Neumann's and Oskar Morgenstern's *Theory of Games and Economic Behavior*. Von Neumann's posthumously published Yale lectures on the subject of *The Computer and the Brain*, are of crucial implicit significance in reading von Neumann's lunatic, long-winded argument respecting economy. On the record, my methods have been, contrary to the British school and its positivist fanatics, the most successful approach to long-range economic forecasting of the recent forty-odd years.

Rachel Douglas/EIRNS

Lyndon LaRouche (left) speaking at an April 1994 "President" program sponsored by Pobisk Kuznetzov at the Russian Academy of Sciences in Moscow.

Rachel Douglas/EIRNS

Dr. Kuznetzov in the audience. LaRouche writes of Kuznetsov, who died in 2001, "I, like many who knew him and his work, miss him very much today."

passing, peripheral, if useful way.

It was only from 1994 on, through benefits of my associations with two now-departed Russian friends, the most remarkable Professor Taras Muranivsky and the scientist Pobisk Kuznetzov, among others, that I grew more confident of the existence of special, crucially important affinities between Academician Vernadsky's and my own lines of work in redefining a science of physical economy. The agreement, and some points of disagreement, in my own and Pobisk's views, were presented to a relevant Moscow scientific audience during that period.[3] In materials bearing on Vernadsky's work which were subsequently made available to me through some of my associates, I was convinced that I had sufficient evidence to draw out those connections between my own work and Vernadsky's which were featured in my 2001 *The Economics of the Noösphere*.[4] The evidence then in hand was sufficient to have shown me that the problem implicitly resolved by his argument, as known to me then, was largely congruent with my own original discoveries in the field of a science of physical economy.

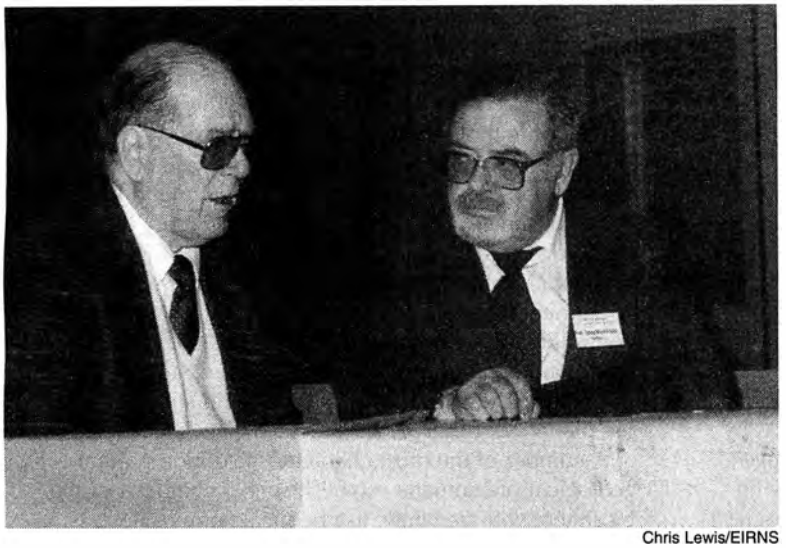
However, even then, during the late 1990s and beyond, while I was certain of the validity of Vernadsky's statement describing the central features of his stated notion of the Noösphere, I had yet to discover evidence satisfying me in respect to some important details of his approach to his original discovery of that conception.[5]

Recently, during the recent fortnight, a collaborator of mine forwarded copies of some translations of Academician Vernadsky's work, work made available through a collection supplied to Columbia University by Vernadsky's son, Professor George Vernadsky. One of these, a 1935 work, "On Some Fundamental Problems of Biogeochemistry," includes a crucial margin of additional validation of my own conclusions respecting the method which underlies Academician Vernadsky's later argument on the distinction of the Noösphere from the Biosphere. I brought a copy of that 1935 paper along with me as a subject of work to be done during

3. The debated issue on that occasion was on the definition of "energy." My host, Pobisk, began his lecture by defending the standard reductionist doctrine on that subject, and challenged me to define my principle of anti-entropy accordingly. In my turn, I opposed that definition of "energy" on that occasion, as many other occasions, before and after. The misguided suspicion in certain Soviet scientific insider circles studying my own original proposal for a strategic defense initiative had been that I had somehow acquired knowledge of super-secret Soviet work of the 1970s and 1980s, in which Pobisk had been involved, bearing on the scientific feasibility of such an initiative. I had no such knowledge of Soviet secret work, beyond my conviction that certain known lines in Soviet scientific work pointed to their ability to recognize the feasibility of developments along the lines I was proposing. Otherwise, Pobisk and I got along nicely. I, like many who knew him and his work, miss him very much today.

4. (Washington, D.C.: EIR News Service, 2001) See the work which I referenced in writing that book: *V.I. Vernadsky: Scientific Thought As a Planetary Phenomenon*, B.A. Starostin, trans. (Moscow: Nongovernmental Ecological V.I. Vernadsky Foundation, 1997). In writing what was published as my 2001 book, I had gone no further than this Starostin translation.

5. One crucial, contributing problem in present-day readings of the work of Vernadsky is to be seen as a carry-over of the earlier influence of the implicitly dionysian "ecology cult" of the Cambridge Systems Analysis group on Soviet ideology during the 1970s and 1980s, an influence wielded through the Laxenberg, Austria International Institute for Applied Systems Analysis (IIASA) by such as the U.S.A.'s McGeorge Bundy, and Britain's Club of Rome figures Dr. Alexander King and Solly Zuckermann. Despite some deferences to the Soviet reductionist school in his references to the history of science in the Starostin translation, Vernadsky's strength lies in his actual work in the fields of his original discoveries in physical science; when he departs from that field, his views on the history of social thought, as on the subject of Plato, as expressed in the Starostin translation, are not always defensible scientifically. This was a cause of my cautious approach, until now, to certain material found in the 1997 text.



Chris Lewis/EIRNS

LaRouche with Dr. Taras Muranivsky (1935-2000) in 1996. "It was only from 1994 on, LaRouche writes, through benefit of his association with the "most remarkable Professor Taras Muranivsky and the scientists Pobisk Kusnetzov, among others, that I grew more confident of the existence of special, crucially important affinities between Academician Vernadsky's and my own lines of work in redefining a science of physical economy."

my international travels, and have spent happy hours, while shrugging off jet-lag, in doing my literary duty on this account.

Although the subject of this 1935 paper is the distinction of the chemistry of living processes from those of non-living, rather than the subject of the Noösphere itself, the present relevance of this paper for me, is that, in that location, Vernadsky exhibits emphatically, and repeatedly, the same principle of investigation which underlies what became his later, categorical distinction of the Noösphere from the Biosphere. For both cases, the Biosphere and Noösphere, the common distinction of his method is that otherwise best identified as Bernhard Riemann's emphasis on what he describes as *Dirichlet's Principle.*

I have already emphasized this connection to Riemann in my 2001 *The Economics of the Noösphere,* that Vernadsky himself identified his view of the Noösphere as systemically Riemannian. Back in 2001, I could confirm this in broad terms, as I did then; but I left room for relevant fine points on this account yet to be discovered. A reading of the recently acquired access to Vernadsky's indicated 1935 paper on biogeochemistry, filled in some important blanks left in the material I had considered for my 2001 report.

My acquisition and study of the 1935 paper not only leads me to additional observations on the deep quality of Vernadsky's work on the subjects of both the Biosphere and Noösphere. As that work of his bears on the application of the prospects on development of mineral resources, in my recently published work on *Earth's Next Fifty Years,* everything bearing upon a deeper insight into the implications of Vernadsky's referenced discoveries, is of strategic importance for all humanity today.[6]

Nine Excerpts Considered As One

Immediately below, I have identified nine excerpts from the referenced 1935 Vernadsky paper, which I present now, in sequence, without interrupting that presentation with my own argument, the latter which I have consigned to the elaboration developed following that presentation of the cited excerpts. My intent in this procedure, is to afford readers a general flavor of the point I am emphasizing from within Vernadsky's work, while also pointing the relevant specialists to something which is implicitly of deeper relevance than his work on biogeochemistry as such.

I add, as a preface to presenting those excerpts here, that the nature of the content of the 1935 work, when considered in light of his own later writings known to me on the Noösphere, is such that no significant margin is left for assuming any relevant defects in the English translation which I have consulted in what I have to say here. We are dealing with scientific ideas expressed in ways which rise above the ambiguities of differences in the mother-languages of the medium employed. The validity of the ideas of principle stated is imparted by reliance on the experimental standpoint which the responsible mind must always bring to describing the observed tests of crucial-experimental demonstrations themselves.

However, I caution my readers, in the setting in which I locate Vernadsky's work here, it is my right and obligation to situate my view of his work within the bounds of my own established competence in relevant features of the branch of science known as physical economy. I believe, that by the close of this present report, I will have made clear the relevant lines of division of labor between my own views and his.

First, take the two following, interdependent paragraphs from Section II of his report on the perspectives of the work being conducted at his Laboratory:[7]

> A great part of our work is connected with a study not of the atoms themselves but of chemical elements, of isotopic mixtures. In purely chemical processes all of the isotopes of the same element are manifested in a similar way, Hence, while we remain within the field of purely chemical processes, the chemical element may be identified with the atom, as it is the case in the periodical system of elements. On this the whole chemistry is based.
>
> Proceeding from this general statement, it has been possible to show by the work of our laboratory that the *atomic composition of organisms, plants and animals is as characteristic a feature as their morphological form or*

6. LaRouche PAC, 2005.

7. The Laboratory of Biogeochemistry of the Academy of Sciences of the U.S.S.R. The italicized passages in the quoted excerpts of his paper are copied from the original of the English translation.

physiological structure as their appearance and internal structures. . . . An organism does not show a passive attitude towards the chemical medium; it actively creates atomic composition, it tends to choose, consciously or unconsciously, the chemical elements necessary for life, but as life presents a field of dynamic equilibria, it reflects—both in its composition and in its form—the different physico- chemical properties of the medium. These variations, however, do not change their average, little varying expression.

And, then, in the immediately following paragraph:

A species established by biologists may be characterized in weight or atomic composition as precisely, as by its morphological features, also within a definite range of variations it may characterize a homogeneous living substance—the totality of organisms of the same species, race, jordanons,—as it is characterized by morphological features. In the average numbers, the amounts of atoms, of chemical elements, composing a living organism, are as constant and as characteristic for it as its form, size, weight, etc. It is possible that in the numerical relations of living beings thus expressed, the same harmonious combinations will be found, which are so distinctly manifest in the vividness of the living nature. They should be probably manifested in harmonious relations of numbers in these natural bodies—in living organisms, as numerical relations are harmoniously manifested in the natural bodies of inert nature—in crystals and minerals. The elucidation of this problem is a task of the nearest future.

Next, take the entirety of the concluding paragraph of the paper's Section II for general background and flavor:

We have first embraced by the precise methods 18 chemical elements; now, we are able to make a quantitatively precise study of over 60, and we must comprise all of the 92, if not more,[8] for it becomes clearer and clearer that it is in the biosphere that living matter embraces and controls all or nearly all of the chemical elements. All of them *are necessary for life* and not one of them comes to the organism by chance. *There are no special elements peculiar to life.* There are *predominant* elements. When taken as a whole life comprises the total system of Earth elements, probably leaving aside a few of them, as, e.g., *thorium,* but probably comprising all of them in the different isotopes. Life is a planetary phenomenon and predominantly determines the chemistry, and the migration of chemical elements of the upper shell of the Earth—the *biosphere;* it determines the migration of all the chemical elements. A quantitative investigation of such a migration is the fundamental task of the Laboratory.[9]

Next, consider a series of paragraphs which I have excerpted, for emphasis, from Section III of his report, and, after that, a pair of the opening paragraphs from Section IV.

1. For life the field of life—the *biosphere*—is not a structureless casual Earth's surface—the face of the planet upon which life originated, according to E. Seuss, or the cosmic medium of life according to Cl. Bernard. The biosphere is not only the face of the Earth and not a cosmic medium. The Earth's shell has a strictly definite composition and structure, determining and controlling all the phenomena that take place within it, the phenomena of life included; it is morphologically distinct but closely related to the general structure of the planet.

A number of the most characteristic and important geological phenomena establish such a character of the biosphere with certainty. Its chemical composition, as well as all the other features of its structure, is not casual and is most intimately related to the structure and time of the planet and determines the form of life observed.

And, next:

The biosphere is not an amorphous nature, a structureless part of the space-time, in which biological phenomena are studied and established independently of it; it has a definite structure changing in time according to definite laws. This is to be taken into consideration in all the scientific deductions, in the logic of natural science in the first place; and this is not done. The "nature" of the naturalist is only the biosphere. It is something very definite and delimitated.

And next:

If this structure is called a mechanism, it would be a special, very peculiar mechanism, a continuously changing mechanism—a dynamic equilibrium—never reaching a state strictly identical in the past and in the future. At every moment of the past and of the future time the equilibrium is different but closely resembling. It contains so many components, so many parameters, so many independent variables, that no strict and precise return of some state in its previous form is possible. An idea of it may be given by comparing it to the dynamic equilibrium of the living organism itself. In this sense it is more convenient to speak of the *organized state,* rather than of the *mechanism* of the biosphere.

And, from the first, second, and third paragraphs of III.2:

Life is continuously and immutably connected with the biosphere. It is inseparable from the latter materially and energetically. The living organisms are connected

8. Remember, that this was written in 1936, before the work done on transuranic regions of the Periodic Table.

9. Vernadsky, *op. cit.*

with the biosphere through their nutrition, breathing, reproduction, metabolism. This connection may be precisely and fully expressed quantitatively by the migration of atoms from the biosphere to the living organism and back again—*the biogenic migration of atoms*. The more energetic the biogenic migration of the atoms, the more intense is life. It is nearly dying out or hardly flickering in the latent phases of life, the importance of which in the organized state has not yet been evaluated, but should not be overlooked.

The biogenic migration of atoms comprises the whole of the biosphere and is the fundamental natural phenomenon characteristic of it.

In the aspect of historical time—within a decamyriad, a hundred thousand years,—there is no natural phenomenon in the biosphere more geologically powerful than life.

And, under III.3, the following most relevant pair of paragraphs appears:

The chief geological importance of these masses of substance embraced by life, that seem small when compared to the mass of the biosphere, is connected with their exclusively great energetic activity.

This property of the living substance, having nothing equal to it in the substance of the planet, not only at the given moment, but also in the aspect of geological time, completely distinguishes it from any other earthly substance and makes the distinction between the living and inert substance of the planet quite sharp, the more so that all the living is derived from the living. The connection between the living and the inert substance of the biosphere is indissoluble and material within the geological time-—of the order of a milliard of years, and is maintained exclusively by the biogenic migration of atoms. Abiogenesis is not known in any form of its manifestation. Practically, the naturalist cannot overlook in his work this empirically precise deduction from a scientific observation of nature, even if he does not agree with it due to his religious or philosophically religious premises.

And, then, finally, the four paragraphs opening section IV:

The whole work of the Laboratory is based on such a structure of the biosphere, on the existence of an impassable sharp, materially energetical boundary between the living and the inert substance.

It is necessary to dwell on this point, since it appears to me that in this question there is a vagueness of thought, which impedes scientific work.

We do not proceed here beyond exact empiric observation, the deductions from which are obligatory for the scientist and as a matter of fact for everyone; it is on this observation that he not only *can* but *must* base his work. These deductions may possibly be explained differently, but in the form of *empiric generalization* they are to be taken into consideration in science, for an empiric generalization is neither a scientific theory, nor a scientific hypothesis, nor else a working hypothesis. This generalized expression of scientifically established facts is logically as obligatory as the scientific facts themselves—if it has been logically correctly formulated.

The sharp material energetic distinction of the living organisms in the biosphere-—of the living substance of the biosphere—from any other substance of the biosphere penetrates the whole field of phenomena studied in biogeochemistry.

From that point on, Vernadsky leads the discussion into the region of a Pasteur-Curie conception, a subject of continuing importance for treating the outcome of Vernadsky's life-time work as a whole, but which should be left for discussion at some other occasion, since we must tend to bound the present discussion here within the limits of the scope of that special topic of method which I have posed to be the subject immediately at hand here.

The Significance of Those Examples

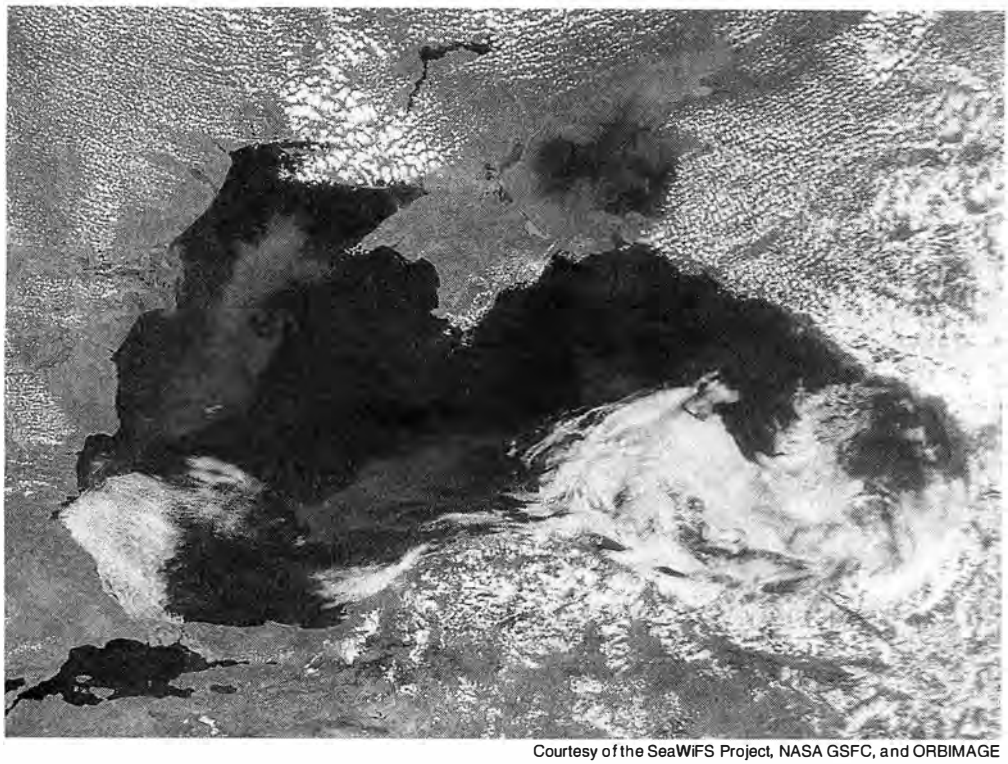
The set of excerpted passages which I have just presented, should remind us of deliberations which should have been familiar from among the most notable features of the greatest known moments of ancient through modern science, especially those highlights of the modern science set into motion by the Fifteenth Century genius, Cardinal Nicholas of Cusa, and such of his explicitly avowed and faithful followers as Luca Pacioli, Leonardo da Vinci, and Johannes Kepler. We must continue attention to the principle expressed by those authors, to include such followers of Kepler as Fermat and Leibniz, and such followers of Leibniz as Carl Gauss, Lejeune Dirichlet, and Bernhard Riemann. The point which I am stressing in this report, is that the methodological approach expressed by the quoted passages from Vernadsky above, should remind us of Gauss's wrestling with a crucial topic of Earth magnetism, also of the related topic, which we encounter under Vernadsky's four paragraphs of his Section IV above, the topic of the development of what Riemann emphasized as Dirichlet's Principle, and also Riemann's own work based extensively on the immediate foundations developed by his own principal teachers Gauss and Dirichlet.

When this cited 1935 material on the Biosphere is taken inclusively into account, there is no reason to doubt that Vernadsky's work is, as he claims in later writings on the Noösphere, authentically Riemannian.[10]

As I have emphasized at the beginning of this report, knowledge of a discovery of principle is obtained only by experiencing the process of its discovery, not by learning recipes, nor by the deductive methods of the reductionists. *What is most significant in my pointing to the referenced excerpts from Vernadsky's 1935 report on methods of biogeochemistry, is the way in which he structures the process of discovery of that principle which separates the biosphere categorically from a part of the universe which is determined only by the principles of non-living processes.*

The same method for defining such a discovery which he describes in the indicated 1935 report, is that which I devel-

10. LaRouche, *op. cit.*



Courtesy of the SeaWiFS Project, NASA GSFC, and ORBIMAGE

The Black Sea, shown here in a satellite image, was created in the melt of the last Ice Age, when salt water flooded an existing fresh water lake, bursting in from the Mediterranean Sea and obliterating coastal settlements.

"Despite the kinds of great 'natural' catastrophes, and also man-made relative dark ages which mankind has endured on this planet," LaRouche writes, "there is a wonderfully stubborn resilience of our species, such that something essential springs up from the ashes of catastrophe, sometimes transmitted from earlier places where human habitation my have been subsequently erased."

oped, in emphatic opposition to Wiener and von Neumann, for defining the underlying, anti-entropic principle of a science of physical economy. On my recent first reading of the 1935 paper at hand, I recognized immediately, that the method he sets forth in that paper for defining the domain of biogeochemistry, provides us evidence of the method he had employed for his subsequent discovery of his concept of the Noösphere, thus filling in some important evidence which I had not found explicitly provided in satisfactory degree in what I had known of translations of his writings on the Noösphere.[11]

I emphasize what I have already stated, that the principle of method expressed by Vernadsky in those cited passages corresponds to what Riemann emphasized as Dirichlet's Principle, a Principle whose footprint jumps up at me in the series of passages from Vernadsky's 1935 document which I have excerpted above. The use of the same method from the 1935 paper, when applied to the subject of the specific distinctions of human behavior from anything met in other living processes, defines the *noëtic* principle of human cognition as distinct from anything otherwise found in the domain of the biosphere.

I emphasize to the present reader, that I am writing this at a time when some of my associates among the LaRouche Youth Movement (LYM) have relived the process of discovery of Riemannian physical geometry to the degree that they have had notable successes in treating some of the essential content of Bernard Riemann's 1857 Theory of Abelian Functions. That is the work by Riemann in which his employ of what he terms Dirichlet's Principle plays a pervasive role. The report I am delivering here, is intended, inclusively, to provoke those readers into developing some useful supplementary insights into the implications of the role of the Dirichlet Principle in Riemann's advanced work. Obviously, once that special part of my intended audience is taken into account, what I present here is relevant for a still broader audience.

1. The Matter of Sphaerics

The method of investigation which Vernadsky expresses in the cited 1935 paper is in the same "archaeological" tradition as that which the ancient Thales and the Pythagoreans adopted as the Egyptian school of astrophysical science known to the Greeks as "Sphaerics."

For example, the term "archaeology" is perhaps the best

11. As I have stressed in an earlier location, to appreciate the work of Vernadsky, one must take into account the aversive circumstances of the hostility his achievements bestirred among the official Marxist-Leninist ideologues of those times and places. The concepts which I reference, as crucial, in this present report, would be deeply resented by any reductionist ideologues, including the most zealous materialists of the F. "Opposable Thumb" Engels tradition in "science." It is only to be added, that the Marxist-Leninists were comparatively innocents on this account, when compared with the virtual criminality of our contemporary positivist and existentialist tribes.

choice of irony for pointing to the need to consider the fact of a turbulent transition which occurred after perhaps something less than 10,000 years of initial melting of the hundreds of thousands of years of glaciation of much of the northern continental hemisphere, during an interval prior to the climactic melting which flooded a great freshwater lake, now known as the Black Sea, with the salt water flooded in from the Atlantic by way of the Mediterranean.[12] *I now emphasize a special kind of archaeology, not usually treated as such, in which a lack of material available on site must be overcome by focussing on what early periods of human existence and development, which, perhaps, occurred in other places, must have deposited as ideas, as if these were footprints, on the physical archaeological site whose evidence we are considering.*

After all, the human species, as distinguished from apes and other animals by the human individual's cognitive powers, has lived on this planet for as long as perhaps a million years, or, perhaps, even much more. The transmission of the cognitive kinds of ideas which are unique to, and everywhere characteristic of the behavior of the human species, must have been transmitted, in significant part, into historical times and places from very ancient dates, and from different places, certainly long, long before 17,000 B.C., including the hundreds of thousands of preceding years of generations, during a time much of the northern hemisphere was under great slabs of glacial ice.

"What is human about the Great Pyramids of Egypt. . . . Is it the stones? Or, is it not something modern man was often reluctant to discover, the ideas expressed in the way those stones were arranged, and in the methods by which those pyramids were constructed? It is tens of thousands of years of astronomy expressed by the physical principles which those stones express. . . ."

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The pyramid at Giza.

Despite the kinds of great "natural" catastrophes, and also man-made relative dark ages which mankind has endured on this planet, there is a wonderfully stubborn resilience of our species, such that something essential springs up from the ashes of catastrophe, sometimes transmitted from earlier places where human habitation may have been subsequently erased.

Thus, ideas such as those expressed by the Egypt of the time of the building of the Great Pyramids, must have been largely developed in other places, from a time when the levels of the oceans were about four hundred feet lower than today, a time even tens of thousands of years prior to the first settlements near the mouth of the Nile of that time, and prior to the changes in climate and geography of our planet brought about by the melting of the earlier great glaciation.

We are looking therefore, from sites such as ancient Egypt, into much earlier, glacial times during which the most advanced cultures of the world were transoceanic, and, as some of Bal Gangadhar Tilak's relevant works point out,[13] the most advanced knowledge was dominated by the role of astronomy in such prominently included functions as astrogation. The very long astronomical cycles referenced by the work on ancient calendars of Tilak and others, and study of the methods employed by Thales, Aristarchus of Samos, Eratosthenes, and others, shows us how such knowledge of astronomy and astrogation was developed by methods implicitly available to any ancient civilization, even of the glacial ages, by cultures which were engaged by the challenge of transoceanic astrogation.[14]

Mankind's earlier attributable science, in the sense of modern physical science, framed man's concept of that which is universal, by looking upward toward the universe in the large. It is definite knowledge, that the birth of science in European civilization, such as the work of Thales and the Pythagoreans, was principally influenced from Egyptian sources falling under the category of *Sphaerics,* not the contrary, reductionist methods typical of Mesopotamia, for example. As the work of Vernadsky in the matters of the Biosphere

12. E.g., Plato, *Timaeus, passim.*

13. *Orion, Arctic Home in the Vedas.*

14. There is a reflection, thus, from distantly ancient times in the work bearing on even "ice age" cultures by the Egyptian Platonic Academy representative of Cyrenaic origin, Eratosthenes. His measurement of the longitudinal circumference of the Earth, from within Egypt, and his measurement of the distance along the arc from Alexandria to Rome, are exemplary. Compare this with Tilak's *Orion* and *Arctic Home in the Vedas.*

and Noösphere should remind us, it is Egyptian Sphaerics which supplied European civilization with its original science, its original notion of science as subsumed by those purely physical-geometrical notions of universality which man recognizes in the astrophysical depths of an Egyptian astronomy which had turned, long before the time of the Pythagoreans, to the long waves of development of astrophysics which were continued into the work of the Eratosthenes whose discoveries made possible the map, crafted by Toscanelli, and used by Christopher Columbus to guide his first voyage of Transatlantic discovery.

The greatest, and most ancient of all archaeological artifacts, are to be found in the domains of astrophysics and its application to such subjects as transoceanic navigation.[15]

If we can fairly estimate the local origins of Egyptian culture as dating from approximately 8,000 B.C., how might the culture reflected in the astrophysical characteristics of the Great Pyramids be traced to roots in the forms of human civilized existence existing under the conditions of glaciation? Implicitly, that is the issue of scientific method which permeates Vernadsky's 1935 design for the further scientific work of his Laboratory in fundamental questions of biogeochemistry. Such were the methods of *Sphaerics* employed by the Pythagoreans and their follower Plato.

What is human about the Great Pyramids of Egypt, for example? Is it the stones? Or, is it not something modern man was often reluctant to discover, the ideas expressed in the way those stones were arranged, and in the methods by which those pyramids were constructed? It is tens of thousands of years of astronomy expressed by the physical principles which those stones express, as we see, similarly, the implications of the Equinoctial cycle expressed by the calendars embedded in Vedic hymns composed in Central Asia more than six thousand years ago.

The way in which the human mind, working in societies over intervals of many generations, generates valid ideas respecting the practicable knowledge of the organization of the processes of our planet, is as much an archaeological artifact as any physical object or written ancient record. This is the case, even if the place where this idea was developed no longer exists to provide us a physical record of that culture's activity. Rather, because of the nature of man, as distinct from the beasts, those ideas are much more the characteristic physical, archaeological expression, the truer artefact of humanity, than any mere physical artifacts in themselves.

A practicable applied science of the way in which the *noëtic* power specific to the human mind develops discoveries of principles and of their applications, should be adopted as the most important of all working archaeological principles. This has reflections in Vernadsky's treatment of the geology of the Biosphere in the 1935 paper, and is the implied challenge for the development of an applied archaeology (i.e., epistemology) of the cognitive domain of human existence.

On this account, the notable characteristic distinction of the work within the domain of *Sphaerics* by the Pythagoreans and Plato, is that it belongs within the category of astrophysics, rather than the mere astronomy of an Aristotelean such as the celebrated Roman Imperial hoaxster Claudius Ptolemy, or the more honorable later astronomers such as Copernicus and Tycho Brahe. This distinction of ancient astrophysics from ancient and modern astronomy as such, is best presented today from the vantage-point of Carl Gauss's crucial 1799 attack on the hoaxes perpetrated by empiricist fanatics such as D'Alembert, Euler, and Lagrange—fanatics imitated by Laplace and Cauchy later. As Gauss made explicit in his later writings on the subject of The Fundamental Theorem of Algebra, the relevant distinction between mere astronomy and astrophysics, as applied retrospectively to the case of the Pythagoreans, is expressed in modern mathematical-physics language as the Gauss-Riemann notion of a physics, rather than a mere mathematics, of the complex domain. This mathematical-physical, rather than merely formal-mathematical view of the complex domain, is indispensable for insight into the powerful implications of Vernadsky's discoveries.

The evidence which qualifies us to say that one ape-like creature is human, and another essentially represents some species of ape, is that characteristic of the human mind which is the well-spring of mankind's ability to effect willful increases of our species' potential relative population-density. The distinction is not, as we know, "tool-making," for which even chimpanzees created in the likeness claimed by F. Engels have shown aptitude. It is creative behavior of the type expressed by the discovery and proof of some universal physical principle. *It is such creative behavior which distinguishes mankind systemically, as the conception of the Biosphere reflected in the quotations introduced above distinguishes living from abiotic processes.*

Let us emphasize this point. This quality of behavior, unique to the human species, is not found in biology, just as Vernadsky emphasized, the principle of life is nowhere found within the ontological bounds of the abiotic domain.

Therefore, in the study of living species we do not define life as a phenomenon of the inorganic laboratory, but only as Vernadsky does, in terms of effects which could not be produced by an abiotic physics. *Life is produced only by life.* Cognition is generated, not as a characteristic of living processes, but as the characteristic impact of the respectively higher principle of cognition upon living processes.

Therefore, the method employed by Vernadsky is the method of systemic studies of fossils. We compare the fossils of abiotic activity with the contrasted fossils of living activity, and contrast the cognitive processes to the fossils of non-human living activity. *Only cognition can produce a cognitive response.* It is the artifacts of cognition which express humanity. It is the fossils of cognitive action which betray the evidence of the existence and character of the human species. Every categorical kind of distinction which Vernadsky cites, as in the sample of excerpts from his 1935

15. A notable precedent is to be found, once again, in the way in which Toscanelli, a close collaborator of Cardinal Nicholas of Cusa, crafted the map of the world which was used by Christopher Columbus to rediscover North America. Despite Venetian lies respecting the distance from Italy to the coast of China, the principles expressed by the crafting of that map are to be traced to the work of the Platonic Academy's Eratosthenes, who measured the longitudinal circumference of the Earth from two points within ancient Egypt. Similar is the case emphasized by Tilak in his *Orion*, of the knowledge of the equinoctial astronomical cycle by a Vedic culture existing in central Asia during the interval 6,000-4,000 B.C.

New York Public Library Picture Collection

Carl Friedrich Gauss
(1777-1855)

Bernhard Riemann
(1826-1866)

Gustav Peter Lejeune Dirichlet
(1805-1859)

paper, has a parallel in distinguishing the content of the Noösphere from that of the Biosphere.

Thus, the difference between the human species and other living entities, lies in the difference in ordering of their accumulation of fossils. We can not see life in the physics of abiotic processes. We can not see cognition, the distinction of the human individual from the beast, in the living matter of the human individual. We see cognition in its artifacts, the artifacts of those creative powers of the individual human mind which can not be found within the bounds of biology. In the Biosphere, we see the power of life manifest in the ongoing ordering of fossils. In the Noösphere, we see, as the relevant class of "fossils," the effects of the noëtic powers of the mind of the individual member of the human species.

In the fossils of the Biosphere, we trace the shadow of the hand of life. In the fossils of the Noösphere, we trace the shadow of the hand of cognition, of the noëtic principle of the sovereignly individual mind.

Look at the physical principle of the complex domain, as made adequately clear by the combination of Riemann's 1854 habilitation dissertation and 1857 Theory of Abelian Functions, in that light.

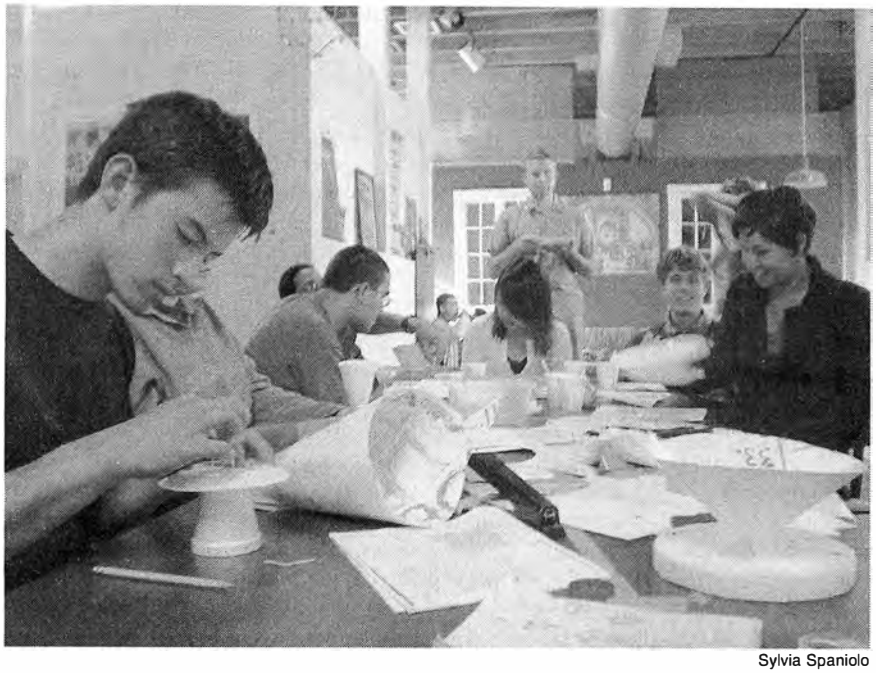
Geistesmasse and Dirichlet's Principle

The notion of the complex domain was a necessary development of mathematics, in order to free mathematics from formal mathematics' perversion, from its enslavement by a reductionist's system of an *a priori* set of so-called definitions, axioms, and postulates. It was Riemann's use of this work by Carl Gauss, to free science from the numbing of the human mind by allegedly "self-evident" definitions, axioms, and postulates, as Riemann did in his 1854 habilitation dissertation; it was Riemann's continuation of that development, strengthened by a legacy of the work of Abel and Dirichlet, which made possible the development of a form of physical science which were uncorrupted by aprioristic or other reductionist presumptions. For this later accomplishment, as by Riemann, the work of Leibniz and Gauss, and of Cusa, Leonardo, and Kepler before Fermat and Leibniz, were among the most crucial modern precedents.

The reductionist's foolish, blind faith in the alleged self-evidence of sense-perceptual experience, depends upon ignoring the elementary fact, that sense-experience is not reality *per se,* but, rather, merely the conscious reflection by the senses, of the impact of some aspects of physical reality upon them. Within the bounds of a mathematics based strictly upon sense-perception-oriented, reductionist views, such as those of a classroom Euclidean geometry, there is no place allowed for the experimentally demonstrated existence of an efficient form of universal physical principle. This problem of representation was solved, largely through the work of Gauss's laying the groundwork for the physical conception of a complex domain. However, the principle expressed by Gauss et al. in this way, was already implicit in the view of *Sphaerics* expressed by the work of the Pythagoreans, and by Plato after them.

Experimentally validatable sense perceptions are real, but are not reality as such. Reality is expressed, typically, by notions such as *life* and *cognition,* two really efficient classes of states of the physical universe, whose effects are efficiently expressed as the experience of our senses, *but which are not themselves the explicit subjects of sense-perception.* We know these so-called transcendent realities, such as life and cognition, only in a way which the notion of the Gauss-Riemann complex domain reflects. Dirichlet's Principle was recognized by Riemann as the necessary ontological glue which made the connection between the two aspects of the complex function truly comprehensible. We recognize these realities in the only way in which they could be recognized, by the successful practice of living beings in general, as known through the application of the creative mental powers unique to the human species.

When the chief work of Vernadsky is considered from this historical vantage-point in science, his successive definitions of Biosphere (life) and Noösphere (cognition), the deepest experimental implications of Riemann's insight into Dirichlet's Principle, and the related implications of Riemann's emphasis



Sylvia Spaniolo

Members of the LaRouche Youth Movement in Oakland, Calif., working on Gauss's conformal mappings.

upon *Geistesmasse,* are made clearer from an experimental standpoint.[16]

I shall explain this, but, that I might do so, first, permit me to resume my attention to what I shall show to be the historical matter of *Sphaerics.*

Sphaerics, as the Pythagoreans and Plato used it, signifies *universality.* Experience shows that we on Earth dwell within a deep universe whose most typical expression for the senses, is motions apparently ordered for our sense-perceptions as within a spherical experience of the universe we observe from the surface of our home planet. It is perceived as a spherical form of physical space-time of unknown, but vast depth.

Within this there are certain observed motions which, when normalized to take into account the motions of the Earth itself, are simply circular or spherical: the universe according to the doctrine of Aristotle, for example, the universe of mere astronomy.

Then, there are seemingly anomalous astronomical motions which do not fit such simplistic explanations; there are higher forms of regularity which express unseen, but efficient universal physical principles acting within and upon the apparently astronomical universe. These higher forms of regularity, in which universal physical principles are defined, is the domain of astrophysics. This defines the essential difference between Copernicus and Kepler, the essential superiority of the work of Kepler over that of Copernicus and Brahe, the difference between mere astronomy and astrophysics.

As the application of knowledge of thermonuclear fusion compels us to view Kepler's organization of the Solar System accordingly, all Earth-bound physical science becomes a subsumed feature of astrophysics. Astrophysics is, thus, the context in which all competent pursuit of physical science must be located, and from which the most crucial aspects of physical science, such as those traced from Thales, the Pythagoreans, et al. to ancient Egypt, must be traced.

The case of the Pythagorean Archytas' construction of the doubling of the cube solely by geometrical methods, is, thus, the prime example of the principle of astrophysics passed down from the Pythagoreans, through Plato's scientific method, to the present. The relevance of Archytas' solution for the constructive exact doubling of the cube, is the relevant provocation leading through Gauss's 1799 attack on the fanatical blunders of D'Alembert, Euler, and Lagrange, to the level of development of physical science associated with the life's work of Riemann. This astrophysical principle is the key to that aspect of the organization of Vernadsky's mind expressed in his approach to defining both the Biosphere and Noösphere. The outline of the adopted tasks set forth in the referenced 1935 paper, is typical of this method.

In the experience represented by the Gaussian complex domain, we combine the notion of the sensed object with the notion of the effect on its motion generated by the unsensed, but efficiently manifested principle. One component is, on principle, a view of the relevant phenomenon within the domain of a spherical universal space-time of sense-experience. The other component is the unseen, but actual universal physical principles acting upon the object of perception. The modern typification of this relationship is the argument underlying Cusa follower Kepler's uniquely original discovery of a principle of universal gravitation, a discovery which marks the modern transformation of mere astronomy into a subject of astrophysics. After that, no longer can motion within the observed universe be attributed to the repeatable regularity of motion, as by the modern defenders of the hoaxster Claudius Ptolemy, but must be traced to the power exerted by an unseen, but efficient and knowable universal physical principle.

When we trace the intellectual history of the idea of the complex domain from the practice of *Sphaerics* by the Pythagoreans and Plato, we proceed in mathematical constructions through the anti-Euclidean, geometrical doubling of the square, to Archytas' geometrical doubling of the cube. The implications of this are made clearer through recognition of the frauds which the Leibniz-hating empiricist ideologues, D'Alembert, Euler, and Euler's protégé Lagrange perpetrated in connection with existence of those cubic roots which are, in fact, implicitly locatable within Archytas' construction. The sit-

16. Cf. *Bernhard Riemanns Gesammelte Mathematische Werke,* H. Weber, ed. (New York: Dover Publications reprint edition, 1953). See Riemann's posthumously published papers in that location. *Geistesmasse* can be roughly translated as "thought object."

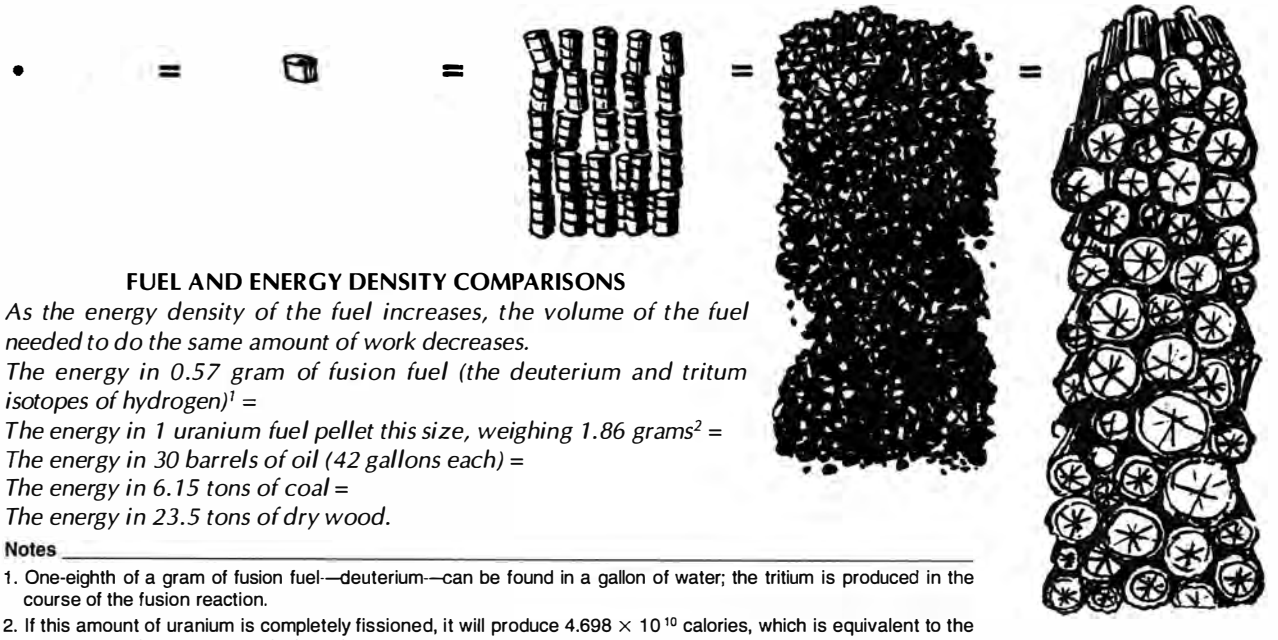
uating of the implications, for experimental *Sphaerics,* of elliptical and higher functions implicit in Kepler's uniquely original discovery of gravitation, and related discovery of the harmonic ordering of planetary orbits, defines the need to go beyond the barest conception of *Sphaerics,* as a precondition for mathematical conceptualization of the existence of any universal physical principle.

So, Kepler summarized this and his related accomplishments in study of the Solar System as a whole, with two directives transmitted as tasks to "future mathematicians." First, the development of a truly infinitesimal calculus, that of the type uniquely developed by Gottfried Leibniz, including Leibniz's catenary-cued, universal physical principle of least action. Second, the importance of the generalization of the implications of elliptical functions shown not only in the characteristic of Earth's orbit, but the composition of the Solar System in general. The latter work was accomplished by contributions from numerous contemporaries of Gauss, chiefly French and German, but especially by Gauss and Riemann. This was the framework for the general development of the notions of the complex domain, and of curvature, by Gauss, and the continuation of Gauss's work by the original discoveries of Riemann.

Yet, we must never lose sight of the fact, that these accomplishments of modern European science are rooted in the Pythagoreans' and Plato's development of the Egyptian heritage of *Sphaerics.* Progress was never simply continuous in history. The emergence of reductionists such as the Eleatics, the materialists, the Sophists, the Aristoteleans, and the Romans, were grave intellectual and moral setbacks to the progress of European civilization. From the historical vantage-point presented by that view of history, the ideas of the Pythagoreans were not actually superseded by the development of those reductionist systems which repudiated the original Pythagorean-Platonic basis. The essential axiomatic issues posed to the Pythagoreans are still among the most crucial issues for scientific method today.

The crux of all ontological issues so posed by the known history of civilization, European civilization in only its specific way, may be stated as a question: "Since universal physical principles are proven to exist with full efficiency, even though they are not themselves objects of sense-perception, how is it

"The increase of the density of power expressed by technological progress from sunlight to wood-burning, to charcoal, to coal and coke, to nuclear, and to thermonuclear power, represents a kind of effect which we may interpret as human willful increases in the intensity of heat per square meter of cross-section of the relevant heat flow. These and related increases of the density of the equivalent of heat-flow are marked by points at which a qualitative change in society's relationship to its environment occurs, a change from a relatively less powerful, to a more powerful system."



FUEL AND ENERGY DENSITY COMPARISONS

As the energy density of the fuel increases, the volume of the fuel needed to do the same amount of work decreases.

The energy in 0.57 gram of fusion fuel (the deuterium and tritum isotopes of hydrogen)[1] =

The energy in 1 uranium fuel pellet this size, weighing 1.86 grams[2] =

The energy in 30 barrels of oil (42 gallons each) =

The energy in 6.15 tons of coal =

The energy in 23.5 tons of dry wood.

Notes

1. One-eighth of a gram of fusion fuel—deuterium—can be found in a gallon of water; the tritium is produced in the course of the fusion reaction.
2. If this amount of uranium is completely fissioned, it will produce 4.698×10^{10} calories, which is equivalent to the combustion of the amounts of oil, coal, and wood shown here.

Source: Dr. Robert J. Moon, 1985

possible that the human mind could conceive a universal principle as an object of the mind? For this, Riemann once borrowed a concept for such objects of thought from the anti-Kantian educational philosopher Herbart, *Geistesmasse.* Later, he expressed this notion by reference to what he identified as Dirichlet's Principle, with notable emphasis on the implications of his own 1857 *The Theory of Abelian Functions,* the theory of the generalized *Riemann Surface.* Vernadsky's definition of the methods of investigation of the Biosphere, and his concept of the Noösphere, are conceptions of this type associated with Riemann's notion of Dirichlet's Principle.

Any validatable physical principle is universal in its intent and scope, even though it may appear to apply to special situations within the universe at large. We may say that any discovered principle appears to have been lurking, waiting for its opportunity to pounce. How can we conceive of a universal principle as an definite object of the mind? A useful response to that question would be the way in which Riemann replaced (but doubtless did not discard) his use of the term *Geistesmasse* by his emphasis on Dirichlet's Principle. We hear little explicitly from Riemann on the subject of *Geistesmasse* again, because the mathematical-physical technical term for that named subject was changed to *Dirichlet's Principle.*

Dirichlet's Principle defines a class of physically efficient mental objects which are never perceived, but whose existence is efficiently demonstrated by crucial types of experiments. *Life* and *cognition* are higher qualities of expression of such objects.

These objects do not exist as real in the vocabulary of the relatively stupefied intellects of the class known to theologians as *Gnostics,* such as reductionists, such as the materialists, empiricists, positivists, existentialists, and as killers in the names of religion, of the type of Dostoevsky's Grand Inquisitor, who may say "Kill them all and let God sort them out."

That much said, let us proceed by taking the further discussion of this subject to my own home-base, the subject of the science of physical economy.

2.
The Science of Physical Economy

The same quality of conceptual challenge posed by Vernadsky's 1935 case for the biogeochemical domain, arises as the qualitatively more profound, central feature of organization presented to us by the subject-matter of economic science. This fact should not be a surprise to any matured thinking person of modern times. Cognition is of a higher order than the abiotic and biotic domains.

It is already implicit in what is written in preceding portions of this present report, that I place the authority of the evidence of a science of physical economy, on the highest level among branches of science. The basis for making that argument is implied in Vernadsky's achievements in defining the Biosphere and Noösphere successively. As I shall restate the case at suitable points later in this present writing, the functional characteristics of the living practice of a well-defined science of physical economy, is the summation of man's capacity for acquiring and proving any kind of new experimental knowledge. It is in observations and experiments conducted from the advantageous position of that pinnacle of man's place in the universe, his place in the Noösphere, that the highest level of knowledge of physical science knowable for man is to be found.

The reader should bear that point in mind, both in reflections on what I have said respecting science above, and what I shall add below.

After all, man is a living organism, whose existence is biologically a part of the Biosphere, and depends upon the Biosphere. Yet, that is not the essential distinction of the human species, nor of the individual member of that species. The essential distinction is "intellectual," a quality in the image of the Creator of the universe, a quality of a higher order than anything experienced in any other living species. Since, as Vernadsky emphasizes, the Noösphere is expanding, relative to the Biosphere, so, just as the Biosphere should be continuing to grow relative to Earth's immediate abiotic domain, we must say that, just as Vernadsky emphasizes that abiotic material is used by the processes of the Biosphere, and exchanged within the abiotic domain, so the biotic features of the human individual, and individuals are used in accord with those higher principles expressed in the Noösphere.

Mankind's historically recent personal entry into exploration of nearby Solar space implies the Noösphere's absorption of the Solar System as of the Earth itself.

These considerations just stated here, are not mere analogies, but appropriate descriptions of the state of affairs already in progress.

Therefore, economy, insofar as it is not expressed in forms of mass human behavior which degrade human beings to the relatively "zero growth" population potential of a species of ape, is an expression of the highest order in the universe explicitly known to us, the Noösphere. Therefore, no one should be astonished to learn that any competent theory of economy must have the most essentially distinguishing characteristics which are to be inherited, so to speak, from knowledge of the participating role of the principles distinguishing both the respective and combined characteristics of the Biosphere and Noösphere. In other words, the same kinds of qualifications which Vernadsky's 1935 work specifies for the Biosphere's distinction from the abiotic domain, and, similarly, for the distinction of the Noösphere from the Biosphere, are the implicit foundations of any competent approach to defining and governing a real modern economy.

In the simplest kind of example of the discovery of a universal physical principle, the apparatus, or its functional equivalent employed by us, contains a feature which corresponds to the demonstration of the principle which is being tested. This is typified by the crafting of machine-tool designs for such purposes as testing an hypothetical experimental principle. If the test experiment has a positive outcome, the relevant aspect of the machine-tool or like experimental design, then becomes the point of departure for designing processes, such as those which might be used in manufacturing, processes which incorporate the function of the discovered principle into regular human practice.

I have often used the image of the "goldfish bowl" to illus-

trate the significance of this kind of experience. This consideration brings us to the point of reflections on a crucial problem of economy considered as a physical, rather than a monetary process.

In contemporary societies so far, most of the people operate on the basis of a set of the typical individual's more or less witting assumptions, some of which are supported by practice, and many frankly absurd. The total set of such assumptions, useful and false combined, is a mind-set which can be likened to the condition of a captive fish in a fishbowl-like container. So, it might often appear to us that the behavior of those people we observe in action is confined within virtual walls, like those of some container, where no such "wall" actually exists outside their own mind. Those people are not responding to the real world; they are confining their actions to a special, imagined world, whose "walls" are not only a combination of both respectable and absurd axiomatic assumptions alike, but also reflect much ignorance of and indifference to many actual principles and conditions existing in the universe.

The simplest classroom illustration of this can be provided by showing the pathological character of the set of definitions, axioms, and postulates associated with a classroom Euclidean or Cartesian geometry. This presents us with a case in which all of these varieties of presumptions are false. Constructions made according to those principles of *Sphaerics* employed by the Pythagoreans and by Plato, lead us toward direct and accurate calculations, whereas attempts to address the same matter within the framework of a Euclidean or Cartesian geometry become a cause for rituals which incur needless frustrations, and often also embarrassing mistakes.[17]

We must concede, however, that the ideal Euclidean or Cartesian mind, while inherently pathological in its own right, might seem to be almost a marvel of orderliness, even a certain excellence, when it is compared with the currently prevalent everyday opinions of most people on the subject of scientific and social behavior in general. No further concession in this matter were needed, or permissible.

In any case, the elimination of false, axiom-like assumptions, or the addition of a discovered, valid universal principle, has an effect which causes the range of behavior to extend into a realm outside the implied walls of that person's prior, goldfish-bowl-like belief-system. The effect of such changes is to raise the power of the relevant human activity by some order of magnitude.

Thus, for example, the increase of the density of power expressed by technological progress from sunlight, to wood-burning, to charcoal, to coal and coke, to nuclear, and to thermonuclear power, represents a kind of effect which we may interpret as human willful increases in the intensity of heat per square meter of cross-section of the relevant heat-flow. My associates and I have often found it convenient to present this fact in the language of "energy-flux density." These and related increases of the density of the equivalent of heat-flow are marked by points at which a qualitative change in society's relationship to its environment occurs, a change from a relatively less powerful, to a more powerful system.

Usually, it is the intensity of the heat-flow, rather than the total amount of heat added, which defines the crucial points in this process. Thus, proceeding from various forms of chemical combustion as a source of heat, to nuclear fission, and then thermonuclear fusion, corresponds to a shift to qualitatively higher forms of physical action. The critical values marked along a scale of such changes, each correspond to successively higher physical states, such that mankind's power over its environment, per capita, and per square kilometer, is increased qualitatively at critical points of qualitative change.

Generally, these qualitative improvements in man's power to exist, are the outgrowth of either discarding some of what are shown to have been false "axiomatic-like" assumptions, or the addition of the use of a discovered new principle, or some combination of both types of actions. This means either "tearing down the walls" of the fishbowl, or moving the walls outward, to encompass more and more of the real universe in mankind's search for a greater scope for the quality of action which is relevant to the increase of, and capacity for survival of the human species. Different categories of what we may measure by the crude yardstick, "energy," may be regarded as presenting us with "walls" which can be breached only through qualitative changes in scope of human practice.

Notably, the principal markers of the qualitative implications of these increases of intensity may be either molecular (distinguishing both abiotic and biotic), atomic, nuclear (e.g., nuclear fission), or sub-nuclear (thermonuclear, matter-antimatter). The quality of action possible, and the order of nature in which the domains for such qualities of action are entered, compel us to give up simplistic ideas about "energy,"[18] and to regard today's popular beliefs about "energy" not as expressing the work of nature, but as the product of superstitions crafted in service of fallible ideologies.

The discovery of practicable approaches to controllable use of resources of these relatively higher order domains, is one of the ways in which walls of the ideological fishbowl of current cultural practice are to be broken.

The willful changes in behavior, in organization and use of power, by means of which mankind maintains and also increases our species' potential relative population-density, express a unique distinction of the human species from all lower forms of life, including, of course, each and all of the varieties of great apes. The resulting distinction of man from the lower forms of life, defines an implied argument which sets man's existence essentially above the Biosphere within which he participates. That is so in the sense, for Vernadsky's 1935 paper, that the principle of life distinguishes the concert of living processes from the abiotic domain. *This distinction is an essential universal principle of real economies.*

What is true of raising the level of the quality of power

17. For example, the assumption of three respectively independent senses of direction in empty space depends, as Euler, in his own 1761 *Letters to a German Princess*, argues against Leibniz in his insistence upon a value of "absolute zero" curvature for any interval of action, whereas experimental physics, such as those of Leibniz's universal physical principle of least action, shows that, contrary to Euler, Lagrange, and Cauchy, for example, no infinitesimal could be so small that it would have "zero" curvature. There is no existing abstract space, time, or matter, but only efficient physical space-time. The absurdity of Euclidean and Cartesian reductionist schemes is about the only thing in geometry which is truly self-evident.

18. The fact that we can measure the height of dogs, cows, and people by the same yardstick, does not allow us to class all as species of yardsticks.

applied, is paralleled by other adoptions of valid added principles to the repertoire of human action.

So, just as the principle expressed by living processes defines a boundary separating the Biosphere from the abiotic domain, so the effect of the principle of cognition defines a Noösphere which is functionally and otherwise distinct from the Biosphere. The three domains, the abiotic, the Biosphere, and the Noösphere, interact, and exchange material with one another, but, as Vernadsky argues in the 1935 location referenced here, the boundary which separates the one process from the others is definite, and of the quality of a lawful universal physical principle. The appropriate conception of such boundaries is the notion of Dirichlet's Principle.

There is not one of the conditions I have selected from what is described by Vernadsky, in the 1935 report, for this kind of distinction of the Biosphere from the abiotic domain, which does not have a correlative in the distinction of the Noösphere—*which is to say the physical economy*—from both the abiotic and the Biosphere, although it is the same abiotic and organic material of the universe at large which is shared among them. The three systems, abiotic, Biosphere, and Noösphere, each have a characteristic universal principle of action, distinct from the other two. In each case, action within that domain is organized according to that characteristic principle of the domain, but the principles typical of each domain, and therefore the result, are different.

However, although it is correct to emphasize the relative distinction of each of the domains from the others, there are higher principles which both define the commonality of the elements of that three-fold domain, and also order the relations among them.[19] This brings us to the challenge represented by the idea of human cognition itself. After treating cognition as creation, I shall return our attention to the matter of the comparison of the ways in which Vernadsky and I have, respectively, obliged ourselves to treat the issues of universal principle associated with the respective phenomena of life and cognition.

What Is, and What Is Not Creation?

The human discovery and use of a discovered universal physical principle, is not only an efficiently physical action. It is one of the essential expressions of the most typical quality of categorically human activity. To follow Vernadsky: *It defines the way in which society (i.e., the Noösphere) organizes the flow of both abiotic and organic materials which it absorbs, uses, and discharges.*

At this point, I must illustrate that point in ways which engage what might be termed the practical experience of economy by any intelligent citizen.

The individual thinks of a useful sort of typical product of agriculture or manufacturing as an independent object, produced by the will of a definite set of people performing the appropriate actions in some definite place. Typically, this produced object may be transferred to some other location, where it might be stored for a while, or purchased, and taken away for consumption.

That individual thinks of the exchange of the product or service produced by one person, for a different product or service by another. Typically, it seems to each that all this can be explained in the language used for financial accounting practice. That kind of belief in accounting is essentially an illusion.

The relationship of the particular product or act of production within an economy, to the economy as a whole, is of a character more than merely analogous to the relationship among all of the components of the Biosphere to one another, and to the abiotic domain.

As Vernadsky emphasized in his published 1935 work principally referenced here, the characteristic feature of the Biosphere as a whole is its development as a whole, a development from a relatively lesser, to a relatively greater significance for our planet, and, implicitly, therefore, the universe as a whole. This development, when it occurs, is characteristically anti-entropic. By anti-entropic, I mean a system which is overall, characteristically anti-entropic, expressing a universal principle of action which is moving its universality as a process from lower to higher states of organization. It does not signify "negative entropy," as a case of local, temporary reversal of a universal entropy.

Thus, life is characteristically anti-entropic.

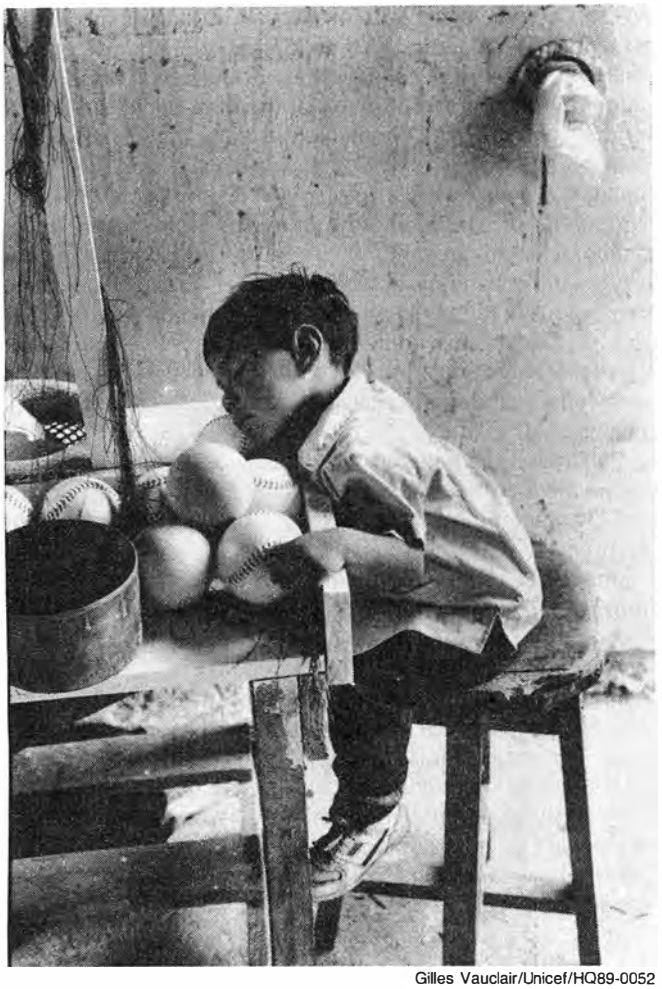
In the case of society, the directed process of increase of the Noösphere, is also characteristically anti-entropic. Absolutely or relatively entropic states may exist within part, or the whole of the Biosphere, or Noösphere at times, but such conditions are inherently pathological states of those phase-spaces.

To restate the same point, say that humanity is typically Promethean, in the sense of that term associated with Aeschylus' *Prometheus Bound*. Recall, that the evil Olympian Zeus condemned the immortal Prometheus to nearly eternal torture for imparting knowledge of the use of fire to human beings.

In other words, Zeus, like the Physiocrat Dr. François Quesnay, and Turgot later, degraded man as Quesnay based his doctrine of *laissez-faire* on the assumption that farmers were, functionally, merely a form of cattle on the titled landlord's estate. Remember that the entire economic dogma of Lord Shelburne's Anglo-Dutch Liberal system was based on the doctrine of "free trade" which Shelburne's lackey Adam Smith plagiarized from the *laissez-faire* dogma of Quesnay and Turgot. Similarly, Bernard Mandeville, the titled "patron saint" of today's Hellish Mont Pelerin Society, based the profit of society on the unbridled license of Enron-like private vice.

In reality, contrary to the Olympian Zeus, man and woman made in the image of the Creator, are naturally creative. Scientific progress based upon the realized effects of the endless discovery and command over universal physical principles, is the essential nature of mankind, the essential nature of the Noösphere. So, as evolution of species of life drives the Earth to higher states of existence, above the abiotic, so the characteristic form of successful action by society is the increase of man's power over the planet, per capita and per square kilometer of the planet's surface. This creative activity, which modern society has recognized in the

19. This kind of distinction corresponds to a notion which Plato addressed, famously, under the topic of the general notion of hypothesis.



Gilles Vauclair/Unicef/HQ89-0052

Globalization's child labor in Honduras. "As a result of this practice of so-called 'globalization,' the potential population-density of the planet is being driven toward levels far below the present level of world population. Globalization is, therefore, the practice of genocide, as in Africa, but also on an increasingly global scale."

benefits of scientific and technological progress, is essentially anti-entropic.

This brings us to a crucial point in the relevant argument. Since the characteristic activity which defines the existence and persistence of the Noösphere is *universal anti-entropy, the characteristic feature of every action within the Noösphere is its relative anti-entropy.* The essential part of what is being exchanged within the economic process as a whole is the relative anti-entropy expressed by the way in which the generation, circulation, and consumption of products is organized.

In this respect, the characteristics of the Biosphere, as Vernadsky and his Laboratory defined it, and Noösphere, as I define physical economies as wholes, are analogous. Everything to which I have referred, on this account, in excerpting Vernadsky's 1935 paper, has a parallel in my methods of a science of physical economy. The relations among the products of the Noösphere have an echo in the relations among the chemical elements circulating within the Biosphere, as in Vernadsky's 1935 account of such kinds of relations between the Biosphere and abiotic domain.

Both domains, the Biosphere and Noösphere, are characteristically anti-entropic, but the characteristics differ qualitatively.

Globalization As a Form of Evil

In its broader expression, creativity is expressed by Classical modes of artistic composition (as distinct from most of today's leading preferences in popular art) in plastic and non-plastic art-forms and their application to other aspects of human practice. Creativity is not something optional in human choices of behavior; that is the only thing which actually distinguishes your choice of political candidate, or painter or musician, from the apes.

It is through that action of the individual human mind, that the repertoire of increased numbers of universal physical principles are not only discovered, but deployed to change man's relationship to the universe qualitatively in an upward direction. *The increase of the Noösphere, relative to both the abiotic domain and the Biosphere, through the fruits of willful cognition, is not only as change in mankind's relationship to the universe; it is an efficient change in the characteristics of action within that universe.* Just as the Biosphere, including its fossil products, are taking over more and more of the Earth, so the accumulation of scientific and technological progress gained through cognition of individual souls, is increasing its domination of the planet relative to the Biosphere.

I had the occasion recently to point out a certain absurdity permeating commonplace beliefs respecting so-called "globalization." That discussion occupies a notably relevant place at this point in my report. It illustrates the point which I have just made on the subject of creativity.

The suggestible, more poorly educated mind thinks of economy as the devotees of Bernard Mandeville, Adam Smith, and the British Foreign Office's Jeremy Bentham did. In fact, contrary to today's more or less conventional, and reigning "monetarist" opinion, it is a rule of thumb in modern economy that approximately half of the true cost, of the indispensable total product of labor within society, is expressed as what we term basic economic infrastructure. As we see in the still continued great margin of poverty among nearly three-quarters of the populations of leading nations with advanced agro-industrial technologies, such as China and India, the want of sufficient elaboration and distribution of truly modern forms of infrastructure expressing modern technology, makes a mockery of the search for less costly goods by runaway U.S. and European investors in what is currently called "globalization."

In such cases, we must see the lower prices of goods produced in those nations as the cause of the terrible misery within as much as 70 percent of the population as a whole. The misery is chiefly a reflection of the long-term failure to pay, and to be able to pay the necessary price of the goods produced at cheaper prices by cheaper labor.

This is reflected in the terrible degree of collapse of the internal economies of the U.S.A., Europe, and others under the so-called "floating-exchange-rate" monetary system of today's

International Monetary Fund (IMF) and World Bank. During these three decades, since approximately the mid-1970s, we have cheapened the price of goods consumed within the U.S.A. and Europe, by exporting production to regions of the world where production is cheaper.[20] The cheapness is the fruit not only of low wages paid in those other nations, but, more significantly, in the lack of the costs of modern forms of basic economic infrastructure.

Therefore, the financier interests controlling this shift in the world economy demand both savagely lower wages for the general populations of the nations to which production has fled, but they also insist upon the suppression of the cost of providing modern basic economic infrastructure in these new markets, while destroying the productive basis in formerly industrialized powers such as those of the U.S.A. and Europe.

In the meantime, in the attempt of Europe and the U.S.A. to compete with the cheaper production, they have engendered in nations with much lower standards of household income, the governments of Europe, the U.S.A., and others, have connived to—in effect—slash their own economic throats, by pushing the prices of labor and investment in infrastructure, down toward "Third World" levels, while, at the same time, driving the prices of goods produced abroad lower, and lower, and still lower, by transferring production from already poor nations of the cheap labor markets, toward nations with the worst imaginable conditions of national life.

As a result of this practice of so-called "globalization," the potential population-density of the planet is being driven toward levels far below the present level of world population. Globalization is, therefore, the practice of genocide, as in Africa, but also on an increasingly global scale.

Much could be said and written of the minds and morals of those influential circles who have concocted and foisted that policy of practice upon our planet. However, for the moment, let us treat this as a scientific fact, as a matter of manifest and massive foolishness, rather than evil intentions.

If this trend, called "globalization," were to be continued, we would reach a critical point, a phase-shift, of self-accelerating physical economic decline globally, at which the potential (e.g., "sustainable") population of the planet would decline to approximately the present population of China, or much less, within a generation or so. Look at the role of investment in basic economic infrastructure in that perspective. Already, throughout most of the world, including the U.S.A. itself, human life itself is becoming very cheap, with that price dropping at a currently accelerating rate. If this continues, a point of phase-shift will be soon reached, at which the level of population will also begin to collapse, and that at an accelerating rate.

All of this global downturn has been concentrated within the most recent four decades, since about the time Harold Wilson assumed the post of Prime Minister of the United Kingdom, since about the time Zbigniew Brzezinski emitted his late 1960s draft for a "technetronic revolution," since about the time of the eruption of the ultra-decadent "68ers" of the "rock-drug-sex counterculture" and that decadent culture's popular fads of LSD, marijuana, and the like.[21] This change, which was first implemented, most notably, in the economies of Europe and the Americas as the highly touted "cultural paradigm-shift" of the recent four decades, is the key to understanding how once powerful and increasingly prosperous nations, such as those of North America and Europe, have also willfully destroyed themselves during the course of these four decades to date, and have gone so far into lunacy as largely praising themselves for making this change.

Otherwise, the pattern of "globalization" which I have just summarily described so, can be studied usefully from a different vantage-point, that of Vernadsky's notion of the Noösphere.

The level of the productive powers of labor achieved through technological progress, is not determined solely by the quality of the technology expressed by the process of farming or manufacture. The productive powers of labor expressed in the process of production of a product for market, are largely, even chiefly determined by the role of the basic economic infrastructure provided as the environment of the acts of production of consumable objects purchased. This basic economic infrastructure is expressed both as the necessary environment of production itself, and as the necessary environment of the population engaged in that production.

When those factors are taken into account, cheaper labor in so-called developing nations is not actually a means for lowering the net physical cost of maintaining the world at a present level of potential relative population-density.

One source of complications which tend to mask the physical realities of "outsourcing," is the difference between current price and the price of the same goods produced and sold under conditions in which the economies of the world taken as a whole were actually engaged in long-term net growth, as tended to be the case during the first two decades in post-war Europe and the Americas, for example. That earlier experience must be compared with what is now shown to have been a long wave of net decline in those regions, a presently persisting decline which began at varying points, from case to case, during the more recent four decades.

The reality of the past four decades begins to be demonstrated forcibly when we take into account the loss of modern production facilities, the falling physical standard of living of

20. In the U.S.A., for example, the net physical standard of household income of the lower eighty percentile of the population, has fallen rather continuously since approximately 1977. Since the U.S. has been incapable of reaching "third world" conditions within its present population-stock, it now imports masses of extremely poor as both legal and illegal immigrants from below its borders.

21. This plunge into decadence, while triggered by the U.S. war in Indo-China and other factors of the middle to late 1960s, was not so much a product of the 1960s, as it was a reflection of the impact of the influence of the counter-cultural Congress for Cultural Freedom on the education and other relevant circumstances of life of the children and youth of the 1950s, especially the suburban population of that time. Vietnam was the detonator, but the 1950s influence of the Congress for Cultural Freedom was the explosive cultural charge which was exploded as the "68er" syndrome. The hypocrisy of the parents of 1950s suburbia matured as what was, potentially, the culturally fatal sophistry all too typical of their children, the "68ers."

the population of a nation considered as a whole, and the rising demand, that costs which nations formerly paid, are being cut, cut, cut, and cut again. It is as if governments, such as that of the Second Administration under U.S. President George W. Bush, Jr., were telling their people, "We are reaching the point that we can no longer afford to keep you alive." The savage cuts in pensions and health care in the U.S.A. and western Europe, are typical of this morbid trend.

What we have termed "basic economic infrastructure" is not only an essential part of the cost of production of a nation's salable output of commodities. The level of technological development and physical capital-intensity of investment in infrastructure is itself a multiplier of the productivity of labor employed in the fabrication and distribution of agricultural and manufactured products.

Step back one step. The lowering of the physical cost of production of goods through scientific and technological progress occurs as much in the form this progress is incorporated in investment in basic economic infrastructure, as in the direct costs of production and distribution of manufactured and distributed agricultural and manufacturing product.

Thus, by shifting production to poorer countries, while allowing the rot and discard of infrastructure and production in nations such as those of North America and Europe, we have lowered the net per capita output of the world as a whole, by lowering the net level of technology expressed as both basic economic infrastructure and the production of marketable goods. We wreck the nations, such as the U.S.A. and Europe, which had the highest relative concentration of investment in maintenance and improvement of productive technology and related basic economic infrastructure, while relying upon production by a small fraction of the total population in so-called developing economies, "developing economies" in which the technological level of production and standard of living is typically low, even very low. What it has become fashionable to describe as "globalization" has been a process of what has become a factually undeniable collapse of the productivity of the planet considered as a whole.

Since the useful physical life-span of much of the basic economic infrastructure on which modern life depends, runs in the order of between one and two generations, the nearly four decades of increasing neglect of replacement and repair of basic economic infrastructure has brought much of the world, North America and Europe most notably, to a much lower level of productive potential than during the 1960s. The time has come at which worn-out infrastructure, and lost investment in modern agriculture and industry, must be replaced rapidly, on a vast scale, or there will be a sudden collapse of productive potential to levels far below that prevalent up to this moment. This approach to the closing phase of a long-term capital cycle, in relevant sections of the world, now defines a precipice for the world economy as a whole during the times immediately before us. Unless there is a sudden, drastic shift back to heavy investment in basic economic infrastructure, the apparently slower long-term decline in economy experienced during recent decades will soon be jolted by a relatively precipitous rate of physical decline, even a collapse.

Economy and the Noösphere

Now, reconsider the following from among those excerpts from Vernadsky's 1935 paper which I quoted at the outset of this report. Reconsider the formulation, now slightly modified: *It,* cognition, *defines the way in which society (i.e., the Noösphere) organizes the flow of both abiotic and organic materials which it absorbs, uses, and discharges.* Compare my own views with those stated by Vernadsky for the case of the Biosphere.

For this purpose, I shall interpolate some restatements, as comments, here, of some of the points I have made above. By repeating them in this way, we may hope to make clearer to the reader what I have already stated on this matter above.

For example, quoting and slightly paraphrasing Vernadsky:

"If this structure is called a mechanism, it would be a special, very peculiar mechanism, a continuously changing mechanism—a dynamic equilibrium—never reaching a state strictly identical in the past and in the future. At every moment of the past and of the future time the equilibrium is different but closely resembling. It contains so many components, so many parameters, so many independent variables, that no strict and precise return of some state in its previous form is possible. An idea of it may be given by comparing it to the dynamic equilibrium of the living organism itself. In this sense it is more convenient to speak of the *organized state,* rather than of the *mechanism* of the biosphere."

Let us apply this image to the economy as I have described it in the immediately preceding pages. Instead of regarding an economy as charlatans such as Mandeville, François Quesnay, Adam Smith, and Jeremy Bentham have done, consider an economy as a kind of organism. This time, consider it as an organism of the Noösphere, rather than the Biosphere.

"Life," in this case the principle of creative reason, "is continuously and immutably connected with the" Noösphere, and also the subsumed "biosphere. It is inseparable from the latter materially and energetically. The living organisms are connected with the biosphere through their nutrition, breathing, reproduction, and metabolism. This connection may be precisely and fully expressed quantitatively by the migration of atoms from the biosphere to the living organism and back again—*the biogenic migration of atoms.* The more energetic the biogenic migration of the atoms, the more intense is life," or, in this case, cognition. "It," in this case, of economy, "is nearly dying out or hardly flickering in the latent phases of life, the importance of which in the organized state has not yet been evaluated, but should not be overlooked.

"The biogenic migration of atoms," or in this case, the materials produced and consumed by the integrated economic process of society as a whole, "comprises the whole of the biosphere, and is the fundamental natural phenomenon characteristic of it.

"In the aspect of historical time—within a decamyriad, a hundred thousand years—there is no natural phenomenon in the biosphere more geologically powerful than," in this case, human "life."

"The chief geological importance of these masses of substance embraced by life," in this case physical economy, "that seem small when compared to the mass of the biosphere, is connected with their exclusively great energetic activity.

The Granger Collection, New York

The Anglo-Dutch Liberal imperial system of the international financial oligarchy is still trying to rein in the technological progress of the modern form of sovereign nation-state republic, which was established with the 1789 U.S. Federal Constitution. Here, an illustration of a British imperial visit of Prince Arthur to colonial India in 1902, and (right) a facsimile of the U.S. Constitution.

"This property of the living substance," in this case, cognition, "having nothing equal to it in the substance of the planet, not only at the given moment, but also in the aspect of geological time, completely distinguishes it from any other earthly substance and makes the distinction between the living and inert substance of the planet quite sharp, the more so that all the living is derived from the living. The connection between the living and the inert substance of the biosphere is indissoluble and material within the geological time—of the order of a milliard of years—and is maintained exclusively by the biogenic migration of atoms. Abiogenesis is not known in any form of its manifestation. Practically, the naturalist cannot overlook in his work this empirically precise deduction from a scientific observation of nature, even if he does not agree with it due to his religious or philosophically religious premises."

"The whole work of the Laboratory," in this case, my discoveries and their use in economy, "is based on such a structure of the" Noösphere, "on the existence of an impassable sharp, materially energetical boundary between the" cognitive "and" non-cognitive "substance."

"It is necessary to dwell on this point, since it appears to me that in this question there is a vagueness of thought, which impedes scientific work." Such is the situation in the practice of economy by nations today.

"We do not proceed here beyond exact empiric observation, the deductions from which are obligatory for the scientist and as a matter of fact for every one; it is on this observation that he not only *can* but *must* base his work. These deductions may possibly be explained differently, but in the form of *empiric generalization* they are to be taken into consideration in science, for an empiric generalization is neither a scientific theory, nor a scientific hypothesis, nor else a working hypothesis. This generalized expression of scientifically established facts is logically as obligatory as the scientific facts themselves—if it has been logically correctly formulated." It is the same for economy today.

"The sharp material energetic distinction of the living organisms in the biosphere—of the living substance of the biosphere—from any other substance of the biosphere penetrates the whole field of phenomena studied in biogeochemistry." It is the same for the Noösphere.

Here, the application of Dirichlet's Principle to the physical processes of economy shines forth. For this purpose, we shall replace the use of the term "life," by "cognition." Both terms are cognates of *creation.* One as applied to the principle expressed by living processes; the second as a higher order of creativity, cognition as defined by man's experimentally validatable discovery of a universal physical, or equivalent principle. In place of Vernadsky's "the biogenic migration of atoms," we have "the cognitive migration of materials."

If we apply that standard for the healthy, normal state of the Noösphere to the evidence of Earth's economy during the recent forty years, especially since the election of President Richard Nixon, we would be obliged to describe the political-economic doctrines of practice of the U.S. economy, and also that of Europe, since that time as clinically insane. The criteria of the cheapest price and highest rate of financial profit have not only failed, but have shown themselves the worst imaginable sort of threat to the future of the human species, and economists of that persuasion defined as a failed species.

Let us, therefore, take the cited 1935 criteria of Vernadsky for the Biosphere as a standard of comparison. Let us adopt the intention to investigate the nature of those pathological features of the recent three-and-a-half decades of the U.S. economy from that vantage-point. We proceed as follows.

The difficulty we face in treating the subject of human creativity, as Vernadsky faced a similar problem of method in his defining the Biosphere, is that, just as the principle of life which is expressed by living processes, is not found within the province of biochemistry, the power which orders the creative powers of the individual human mind is not a biological process as such. In both instances, we are confronted by

something which is universal, and physically efficient, but intangible to the senses.

It is not accidental that problems of this type could not be addressed effectively by an Euler, Lagrange, or other empiricists. When these gentlemen set out to deny the existence of the infinitesimal in Leibniz's catenary-cued calculus of the universal principle of physical least action, they eliminated attention to those discontinuities which betray the presence of a universal physical principle, principles of a type which Classical Platonic Greek science found in Archytas' construction of a solution for the doubling of the cube. Such knowledge can not be reached by any ordinary inductive method, certainly not by the methods of the reductionist inductive-deductive "sciences."

We can, indeed, often recognize the presence or absence of what is properly named human creativity once we have the hang of conducting such investigations, but our knowledge of the principle of intellectual creativity is limited to a kind of evidence similar to Vernadsky's reference to the Biosphere. Hundreds of thousands of years' accumulation of the fossils of the Biosphere, approximate universality in ways which permit systematic investigation of the way in which a principle of life expresses its footprints. In human creativity, the fossils of physical scientific progress work to similar effect.

The work of such outstanding Renaissance figures as Brunelleschi and Leonardo da Vinci has pin-pointed elements of discovery in artistic composition which, fortunately, if seemingly coincidentally, are verifiable as such by physical-scientific methods. When the cross-voice relations within Classical compositions in J.S. Bach and such followers as W.A. Mozart and Beethoven are adduced by demonstration in performance, creativity can be precisely defined in the medium of musical composition. In general, when the forms of ambiguity which are rightly presented as ironies are shown to point to a verifiable truth not otherwise accessible to conventional use of language, a similar proof can be adduced.

In language, as in art, just as life as such seems inaccessible to the senses, it is generally impossible to convey important discoveries by literal use of an established habit in employment of a language. Only a creative intellect can discover the existence of creativity. Creativity can be communicated only by prompting the activation of the creative powers specific to the individual human mind. However, even the dumbest of beasts, or of U.S. Presidents could feel the force unleashed by that human creativity. Thus, it is a fine point of Mosaic theology, and the theology of Plato's *Timaeus,* that only man can know the unseen God, although the universe must feel His effects.

In other words, can we know the principles of a sane economy by applying the methods which Vernadsky applied to the Biosphere, to the economy defined as an expression of the Noösphere? The question is thus posed: Would we then be using the model of the Noösphere as a trick for understanding the economic process, or is it also the case, that knowledge of the physical economy, viewed in this way, is indispensable for probing the Noösphere with a precision lacking in the methods actually developed in any record of the work by Vernadsky?

3.
Ancient and Modern Society Today

The most significant scientific problem to be faced in efforts to define society for these purposes, is that the modern society has systemic characteristics which do not exist in ancient and medieval forms of European society. Moreover, the prevalent practices of national economies today are an awkward mixing of modern economy with a superimposed relic of medieval society.

The chief common problem of today's study and application of a habit called "economics," is that the prevalent, world-wide view of the subject itself has been shaped by that tradition of Venetian financier-aristocratic usury whose product is known today as the intrinsically imperial Anglo-Dutch Liberal system. This view is typified by Mandeville's Enron-like promise that great good can come only from the unhampered proliferation of small-minded private acts of evil. What, then, if we put aside the superstition that the interest earned on loan of money is the Cain-raising Adam and Eve of economy? Why should we tolerate the existence of a creature which has shown itself the author of such pernicious doings as wild money has often done, as with the pestilence of financial-derivatives speculation today, and that on a tremendous scale, now an absolutely unpayable sum, many times greater than the total annual product of the planet as a whole?

This Anglo-Dutch Liberal financial system on which the fanatical doctrines of our contemporary monetarists are premised, is most explicitly a relic of a form of medieval soci-

ety known as the ultramontane system, established as an alliance of the medieval Venetian financier-oligarchical system with the Norman chivalry. Like ancient society, medieval ultramontane systems subordinated the great majority of the population to the status of human cattle, defining social relations in a way echoed by the argument on behalf of the dogma of *laissez-faire* of the Physiocrat François Quesnay. Quesnay's argument, from which the British East India Company's Adam Smith derived his "free trade" dogma, was, as I have already emphasized above, an echo of the doctrine of the Olympian Zeus from *Prometheus Bound,* insisting that mankind not be permitted to have knowledge of the use of "fire"—i.e., universal physical principles.

In the contrary form of society, the modern sovereign nation-state republic otherwise named a *commonwealth,* the principle of organization is called *the general welfare principle.* In this organization of society, the ideas corresponding to fundamental principles of science circulate more or less freely and abundantly in society. Thus, in the typical ancient and medieval society, the noëtic principle is not the characteristic mode of organization of the society as a whole, whereas, in that modern European sovereign republic which is sometimes referred to as a commonwealth, the noëtic principle is the characteristic form of action within the social process.

Although the principle of the republic committed to the promotion of the general welfare is ancient knowledge, as the cases of Solon of Athens, Socrates, and Plato typify this, the constitution of nation-states based upon the principle of progress in the promotion of the general welfare dates from the Fifteenth Century Renaissance and such exemplary cases as France under Louis XI and the application of Louis's principle by England's Henry VII.

The situation became complex with the resurgence of the power of the Venetian financier-oligarchy as a result of the Ottoman conquest of Constantinople. From the expulsion of the Jews from Spain by the Inquisition in 1492, until the 1648 Treaty of Westphalia, the Venetian faction used religious warfare and persecution, as in Karl Rove's Flagellant-like political following in the U.S.A. today, as a weapon to divide the emerging modern European nations against one another. The weakening of the power of Venice as a state power during the Seventeenth Century led to the continuation of the Venetian model of quasi-imperial rule by the Dutch and English India Company models, based on the special doctrine, called empiricism, of Venice's Paolo Sarpi, a doctrine which has dominated world finance, and the popular ideology of Europe and other locations, since the February 1763 Treaty of Paris where London's imperial supremacy was first established in the interest of the British East India Company at that time.

The model modern form of sovereign nation-state republic for today was established with the 1789 U.S. Federal Constitution; but, the chain-reaction effects of the French Revolution and Napoleonic rule and ruin, combined with Anglo-Dutch Liberal corruption, isolated the young U.S.A. for an extended period, until the U.S.A.'s emergence as a world power during 1863-1876 and its emergence as a leading world power under President Franklin Roosevelt.

Thus, we have two leading "models" of European-style economies today. The Anglo-Dutch Liberal imperial system of international financier-oligarchical hegemony, into which the U.S.A. itself has been, unfortunately, significantly assimilated, versus the true modern nation-state system typified by the often misused principles on which the U.S. Constitutional system was founded. In the latter system, we have the basis for what might be termed a Vernadskyian model of Noösphere republic. The process of "globalization" which is threatening the extinction of civilization today, is a product of that Liberal tradition.

The complication arising between the two systems, the American System and the Anglo-Dutch Liberal system, is the fact that the role of technological progress has persisted until now as a determining economic and also military strategic factor, as the U.S. demonstrated during the 1939-1945 war. This factor has been such that nations under the Anglo-Dutch Liberal model, which are naturally better fit by ideology and temperament for a quasi-feudal form of society, than a modern, scientifically progressive agro-industrial culture, have nonetheless been unable, until now, to free themselves from a strategic compulsion to maintain society on the basis of a commitment to continuation of scientific-technological progress. The attempt to consolidate the form of imperialism called "globalization," is an effort to rid the world, once and for all, of everything which modern European civilization had accomplished.

Thus, we must face the ugly truth, that the post-1964 rise of the "rock-drug-sex youth-counterculture" and the insurgence of "environmentalism," represent an effort of the neo-Venetian, Anglo-Dutch Liberal interest to free itself from the strategic threat which scientific-technological progress constitutes for an attempted continuation of financier-oligarchical hegemony.

Since 1789, the principal alternative to the Anglo-Dutch Liberal model has been what is known as the American System of political-economy, a system which is implicit in the composition of the U.S. Federal constitutional republic.

If the U.S.A. now comes back to its senses, pulling back from the terrible holocaust which the architects of the American oligarch George Pratt Shultz's Bush II Administration have unleashed, we have one last chance to stop the plunge toward global Hell. If we succeed in doing that in the U.S.A. itself—with whatever cooperation we might find for that noble enterprise—the mission of a community of perfectly sovereign nation-states will be to use the U.S. revolutionary model of 1789 as the rallying point for a system of international cooperation among sovereign states, a system we might have had but for President Franklin Roosevelt's most untimely death.

Then, the ideas associated with Vernadsky's conception of Biosphere and Noösphere will provide a needed added guidance for new global forms of cooperation among sovereign commonwealths. Then, the ideas expressed and otherwise reflected in the foregoing pages will become a possible reality for mankind as a whole.

Lyndon H. LaRouche, Jr., a member of the 21st Century *scientific advisory board, is an economist and world statesman.*

On Some Fundamental Problems of Biogeochemistry

In Connection with the Work of
the Laboratory of Biogeochemistry of the Academy of Sciences of the USSR[1]

by V.I. Vernadsky
Member of the Academy of Sciences of the USSR

Data: AVHRR, NDVI, Seawifs, MODIS, NCEP, DMSP and Sky2000 star catalog;
Texture: Reto Stockli; Visualization: Marit Jentoft-Nilsen

The Earth at night: A satellite view of the electrical lights created by man's activity in the biosphere.

I

Biogeochemistry, which is a part of geochemistry and has peculiar methods and peculiar problems of its own, may be finally reduced to a precise quantitative mathematical expression of the living nature in its indissoluble connection with the external medium, in which the living nature exists. A living organism thus acquires an aspect different from the one it has in biology; it is expressed in numbers of atomic or weight composition, in physical, quantitatively expressed, manifestations of the space it occupies, in numeral energetical expressions of the work it does in the space of life upon our planet.

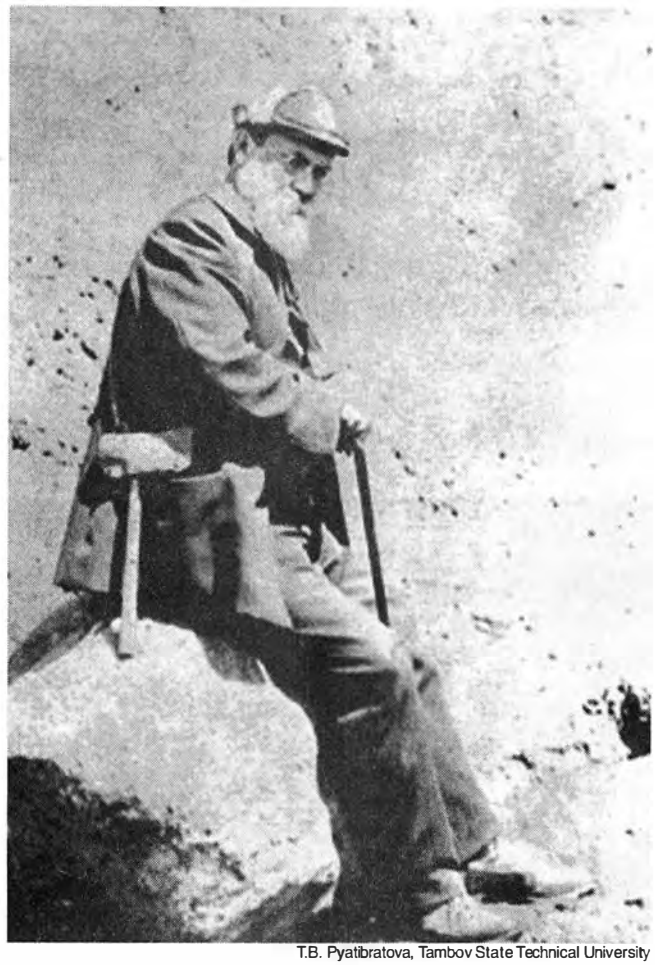
Life in the biogeochemical aspect is the living matter of the biosphere, that is, the total of all the living organisms present in the biosphere at a given moment. Thus the living organism itself, expressed in numbers, is a new independent expression of the same phenomenon, which the biologist views in a vivid physiological and morphological expression of the innumerable forms of life. Between these precise and scientific expressions of life relations might be and should be sought for.

Biogeochemistry is, as shown by its very name, a scientific study of the phenomena of life in the aspect of atoms.

Hence, it seems to me that in the phenomena of life we may approach in a new way a number of fundamental problems of life, on one hand, and on the other, relate the biological phenomena. with the branches of science dealing with

atoms; i.e. with that field of science, which distinguishes our epoch from the preceding ones. It is in this fundamental distinction of biogeochemistry from the other biological sciences that lies its importance and its interest for the biologist.

At present, we may quite definitely state that biogechemistry penetrates as far as atomic properties, and is not restricted only to the properties of chemical elements, since we may study the different reaction of life to different atoms of the same chemical elements, the different relation of life to the isotopes of the element. It was already evident at the first attack on biogeochemical phenomena that the problem could be advanced as a feasible one in this aspect. This was done by the author on the basis of an empiric generalization of scientific facts at the Academy of Sciences in 1926, ten years ago, and the problem was at once included in the plan of our Laboratory. At present, the problem may be treated with greater precision and assurance, since for hydrogen and potassium the distinction between their isotopes in biogeochemical processes may be considered as settled.



T.B. Pyatibratova, Tambov State Technical University

Vladimir I. Vernadsky (1863-1945)

Until recently the isotopes in the Earth's crust were distinguished by their effect only in radiochemical processes: In this way the problem was treated for potassium by the physiologists Zwardemaaker in Holland, and Stoklasa in Czechoslovakia. The new investigations carried out by Brewer in Washington in 1936 have shown that radiochemical processes have nothing to do with this, since both isotopes of potassium, with the atomic weights of 39 and 41—the ratio between the amounts of the latter varying in accordance with life processes—are not radioactive.

The problem we advanced in 1926 has never since left the field of vision of the Laboratory, but the circumstances prevented its development in the proper way. In 1931, the investigations of V.G. Khlopin and M.A. Khlopina-Pasvik showed for pea grains that within the range of *chemical* determination of the atomic weight, the atomic weight of potassium in the pea remains unchanged; they recognized, however, that this does not settle the question, since the variations may be of a lesser order, than the one detectable by their method.

Still earlier, at the same Laboratory, an attempt had been made to use more sensitive methods, but the construction of Dempster's apparatus, started nine years ago, proved to be beyond the possibilities of the Laboratory. After we had moved to Moscow, our position changed for the better, and the discovery of Brewer, who used an improved mass-spectrograph of Dempster, found us already engaged in the construction of the same mass-spectrograph and of another one, of J.J. Thomson's system, and of an apparatus for the determination of isotopes by a superfine spectrography of atoms. I hope that we shall be able next year to elucidate the problem.

At the same time, by courtesy of my son G.W. Vernadsky, professor at Yale University, New Haven, we have now obtained the necessary material for verifying Brewer's numbers, the material from those gigantic *Macrocystis* algae of the Pacific Ocean, upon which Brewer worked. From this material we extract potassium, which should be changed by the life process.

I hope to be able to report of the results of this work in the current academic year.

We are faced with a general problem. Is the change of the chemical element with a different atomic weight by the life process restricted to some few chemical elements, such as hydrogen and potassium, or is this a phenomenon common to all the organisms and all the chemical elements? Don't we have in this biogenic change of the atomic weight one of the numerous manifestations of a sharp material and energetic distinction of the living matter and the inert, which are observed in all of the biogeochemical problems? I shall return to this question later on.

This question may be solved only experimentally.

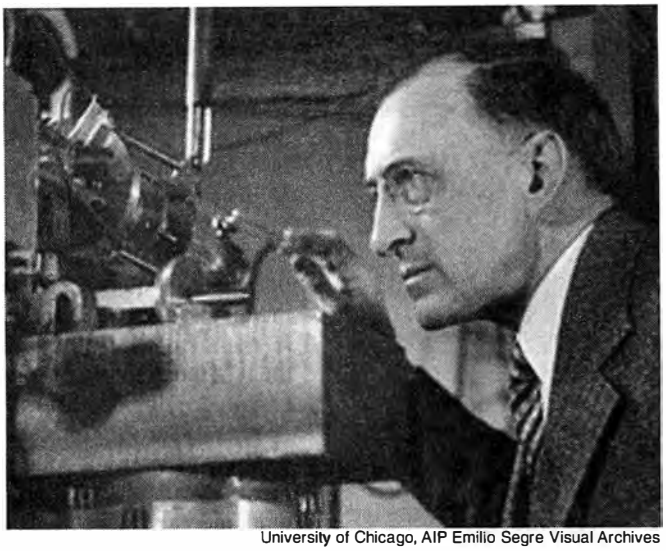
Likewise, only experiment may show the part played by life in the variations of the atomic weight of the chemical elements, which are only just beginning to be observed in the geochemical processes in the Earth's crust and which up to now have been neglected.

This study cannot be only our object, since the change of the atomic weight is not connected only with life. It is a subject of geochemical investigation. The Laboratory restricts itself to the study of the biogenic change of the atomic weight; H, K, Mg, Fe, Zn await their turn in the

investigation.

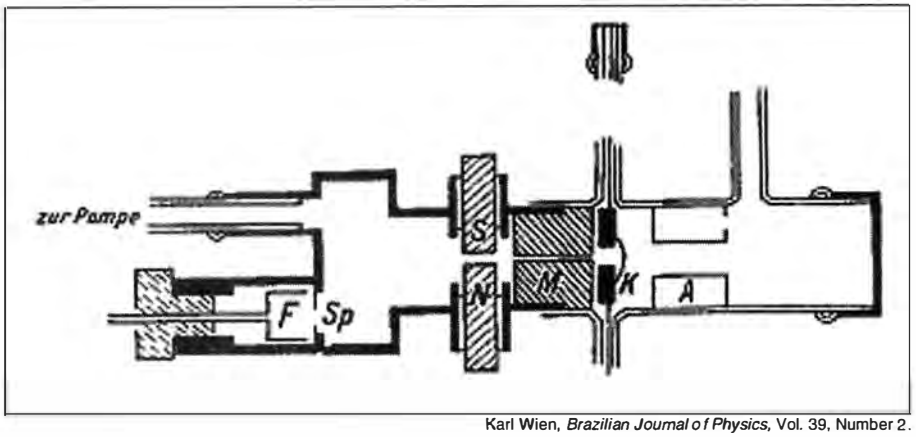
We cannot, however, overlook the other physiological side of the problem, when it is possible to advance it; that is, the question of the mechanism of the action of the organisms upon the isotopic mixtures of elements. We cannot treat this subject ourselves. But since with respect to potassium, the Laboratory will have at its disposal biogenic potassium with a different atomic weight, it is necessary to undertake the study of its vital properties.

It is most important to elucidate the physiological side of the phenomenon both for plants and for animals. With respect to plants and microbes we hope to receive assistance from the laboratories of D.N. Prianishnikov. Negotiations are conducted with the laboratory of A.V. Palladin, at the Ukrainian Academy of Sciences in Kiev, concerning a joint investigation of the problem as far as animals are concerned. The material of the potassium biogenically changed should be fully utilized.



University of Chicago, AIP Emilio Segre Visual Archives

Arthur J. Dempster (1886-1950) developed the mass spectrometer, which he used to discover many isotopes, including U-235. In this schematic of his spectrometer, ions are detected by means of a Faraday cup F behind a slit Sp. The poles of the magnet, S and N, are also the electric deflection plates, and M is ion shielding.



Karl Wien, *Brazilian Journal of Physics*, Vol. 39, Number 2.

II

A great part of our work is connected with a study not of the atoms themselves but of chemical elements, of isotopic mixtures. In purely chemical processes, all the isotopes of the same element are manifested in a similar way. Hence, while we remain within the field of purely chemical processes, the chemical element may be identified with the atom, as it is the case in the periodical system of elements. On this the whole chemistry is based.

Proceeding from this general statement, it has been possible to show by the work of our Laboratory that the atomic composition of organisms, plants, and animals is as characteristic a feature as their morphological form or physiological structure or as their appearance and internal structure. It should be noted that the elementary chemical composition of living organisms of the same species taken at different times, in different years, at different places, for instance in Kiev or in Leningrad, varies less than a natural isomorphous mixture of minerals, easily expressed by stoichiometric formulas. The composition of different species of *Lemnae* or *Insects* is more constant than the composition of orthoclases or epidotes from different localities. For organisms there is a narrow range within which the composition varies, but there are no stoichiometric simple ratios for them. An organism does not show a passive attitude towards the chemical medium; it actively creates atomic composition, it tends to choose, consciously or unconsciously, the chemical elements necessary for life, but as life presents a field of dynamic equilibria, it reflects—both in its composition and in its form—the different physico-chemical properties of the medium. These variations, however, do not change their average, little varying, expression.

A species established by biologists may be characterized in weight or in atomic composition as precisely, as by its morphological features, also within a definite range of variations it may characterize a homogenous living substance—the totality of organisms of the same species, race, jordanons—as it is characterized by morphological features. In the average numbers, the amounts of atoms, of chemical elements, composing a living organism, are as constant and as characteristic for it as its form, size, weight, etc. It is possible that in the numerical relations of living beings thus expressed, the same harmonious combinations will be found, which are so distinctly manifested in the vividness of the living nature. They should be probably manifested in harmonious relations of numbers in these natural bodies—in living organisms, as numerical relations are harmoniously manifested quantitatively in the natural bodies of the inert nature—in crystals and

Ministry of Agriculture and Lands, British Columbia, Canada

A small piece of the massive kelp, Macrocystis, *which was being studied by A.K. Brewer and others in the 1930s for evidence of isotopic fractionation of potassium. Mass spectrometry technology had not yet advanced enough to show it convincingly.*

minerals. The elucidation of this problem is a task of the nearest future.

The greater part of the personnel of the Laboratory is engaged in the study of the problem of the elementary chemical composition of living matter. I have already made reports at the Academy dealing with this side of the work of the Laboratory carried on under the supervision of A.P. Vinogradov. In the 6th volume of the *Transactions* of our Laboratory, now prepared for press, new numbers will be published, which are the result of an eight-year-long work. It may be assumed that in all the cases so far investigated we find a confirmation of the fundamental principle of biogeochemistry, namely, that numerical biogeochemical features are specific, racial, and generic characteristics of the living organisms. As yet it has been possible to establish it precisely for many species of plants and insects. But it is already clear that this is a general phenomenon. The relations are not so simple as one could have presumed. Many questions evidently arise that require biological criticism. I shall not, however, dwell upon this work for the present, for I think that the recognition of its biological importance for wide circles of naturalists is now beyond any possible doubt. It is but necessary to extend and develop in greater detail the work of the Laboratory.

We have first embraced by the precise methods 18 chemical elements; now we are able to make a quantitatively precise study of over 60, and we must comprise all of the 92, if not more, for it becomes still clearer and clearer that in the biosphere the living matter embraces and controls all or nearly all of the chemical elements. All of them are necessary for life, and not one of them comes to the organism by chance. There are no special elements peculiar to life. There are predominant elements. When taken as a whole, life comprises the total system of Earth elements, probably leaving aside but few of them, as, e.g., thorium, but probably comprising all of them in the different isotopes. Life is a planetary phenomenon and predominantly determines the chemistry, the migration of chemical elements of the upper shell of the Earth—the biosphere; it determines the migration of all the chemical elements. A quantitative investigation of such a migration is the fundamental task of the Laboratory.

III

It is to this planetary nature of life, in so far we lay it at the base of the scientific work of the Laboratory, that I intend to call your attention for as short a time as possible.

The following general statements based on the great totality of scientific facts exactly established should be taken as starting points:

(1) For life the field of life—the biosphere—is not a structureless casual Earth's surface—the face of the planet upon which life originated, according to E. Suess, or the cosmic medium of life according to Cl. Bernard. *The biosphere* is not only the face of the Earth and not a cosmic medium. This Earth's shell has a strictly definite composition and structure, determining, and controlling all the phenomena that take place within it, the life phenomena included; it is morphologically distinct but closely related to the general structure of the planet.

A number of most characteristic and important geological phenomena establish such a character of the biosphere with certainty. Its chemical composition, as well as all the other features of its structure, is not casual and is most intimately related to the structure and time of the planet and determines the form of life observed.

The biosphere is not an amorphous nature, a structureless part of the space-time, in which biological phenomena are studied and established independently of it; it has a definite structure changing in time according to definite laws. This is to be taken into consideration in all the scientific deductions, in the logic of natural science in the first place; and this is not done. The "nature" of the naturalist is only the biosphere. It is something very definite and delimitated.

If this structure is called a mechanism, it would be a special, very peculiar mechanism, a continuously changing equilibrium—a dynamic equilibrium—never reaching a state strictly identical in the past and in the future. At every moment of the past and of the future time the equilibrium is different but closely resembling. It contains so many components, so many parameters, so many independent variables, that no strict and precise return of some state in its previous form is possible. An

idea of it may be given by comparing it to the dynamic equilibrium of the living organism itself. In this sense it is more convenient to speak of the *organized state,* rather than of the *mechanism* of the biosphere.

The biosphere may be precisely expressed quantitatively in atoms—like the living organisms; it has definite boundaries, which seem to be determined by the absence of conditions for the stable existence of the liquid phase of water. It extends upwards to the boundaries of the stratosphere, to within about 20 km from the level of the geoid, where water in all forms is practically and probably altogether absent, and downwards to 3-4 km below the land where the liquid phase of the water ceases to exist, and its gaseous phase begins to predominate. Here the anaerobe life begins to be prevalent. Under the ocean bottom it does not seem to extend down to a considerable depth. But here our knowledge is so meager that new exact facts must be awaited. The latent forms of life—in a disseminated inert state—extend far beyond the biosphere both upwards and downwards.

The chemical composition of the biosphere is sharply distinct from that of the Earth's crust, but it is not known to us with any degree of sufficient precision.

The "clarks" of the biosphere are different from those of the Earth's crust. Their precise determination is necessary for many problems having both a scientific and a purely practical importance and reaching far beyond the scope of problems treated in our Laboratory. For their determination, cooperation with other scientific institutions is necessary. At present we advance as a general task for the cooperation of a number of scientific institutions of our country, the development of a table of clarks (means percents of chemical elements) of the biosphere during the nearest few years.

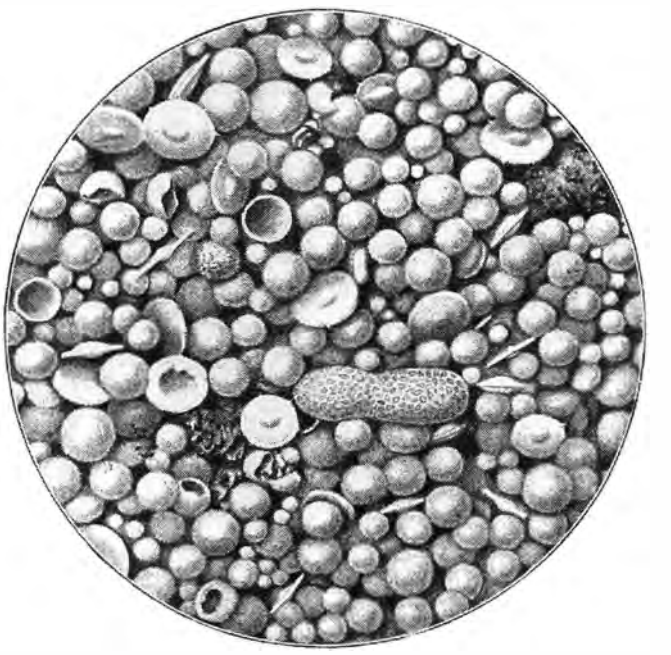
The table of clarks of the biosphere must form a solid base for the whole work of our Laboratory. It is no less indispensable for a scientifically correct treatment of the applied geology and mineralogy.

The Laboratory has started negotiations, concerning a cooperative solution of the problem (undertaking itself a part of the work) with Lomonosov, Petrographical and Soil Institutes of the Academy of Sciences, with the Oceanographic Institute, the Institute of Fishing, the chief Geophysical Observatory, and the Radium Institute. I hope that in the near future the first conference will be held at the Academy.

(2) Life is continuously and immutably connected with the biosphere. It is inseparable from the latter materially and energetically. The living organisms are connected with the biosphere through their nutrition, breathing, reproduction, metabolism. This connection may be precisely and fully expressed quantitatively by the migration of atoms from the biosphere to the living organism and back again—the biogenic migration of atoms. The more energetic the biogenic migration of the atoms, the more intense is life. It is nearly dying out or hardly flickering in the latent phases of life, the importance of which in the organized state of the biosphere has not as yet been evaluated, but should not be overlooked.

The biogenic migration of atoms comprises the whole of the biosphere and is the fundamental natural phenomenon characteristic of it.

In the aspect of historical time—within a decamyriad, a hundred thousand years—there is no natural phenomenon in the biosphere more geologically powerful than life.



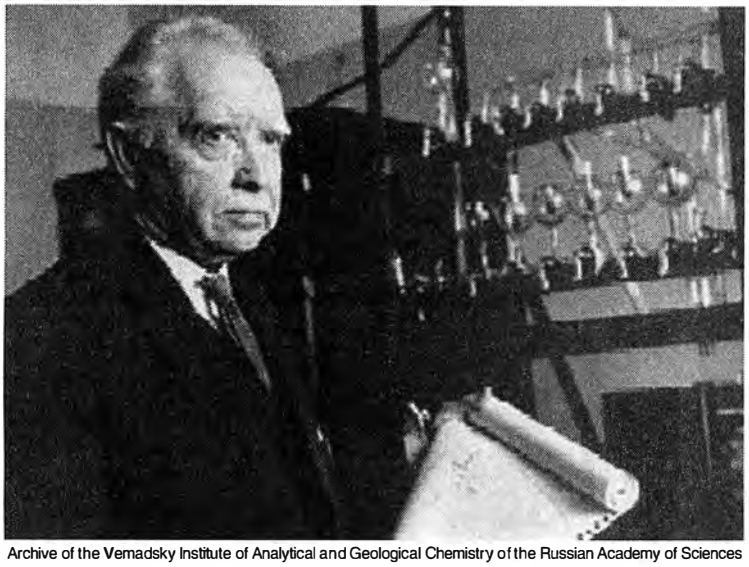
From: *Aus den Tiefen des Weltmeeres*, by Carl Chun, 1903; Courtesy of NOAA

Radiolarians dredged from the seafloor. These single-celled creatures form skeletons of silicates. The fossils of such creatures settle in great masses on the seabed, forming much of the sedimentary layers over geological time.

(3) In the building and in the energetic aspect of the biosphere, three forms of the matter should be strictly distinguished: (1) the inert matter, created without direct participation of life; (2) biogenic matter, such as coals, oil, most of the limestones, etc., and finally (3) the living matter—the totality of the disseminated and separate living organisms.

The predominating mass, the whole skeleton of the biosphere, consists of inert matter, in which silicates, alumosilicates and their analogues are overwhelmingly prevalent in weight and in number of atoms. They compose the skeleton of the biosphere. The mass of biogenic substance for the biosphere constitutes some percent, much over 10, probably over 20 to 30 percent by weight. Here we return in a quite different scientific environment—to Lamarck's natural philosophic idea of the material planetary significance of life. Assuming the biogenic genesis of that manifestation of matter, which we call at present chemical elements, Lamarck considered the material substance of our planet to have been created by life. This we have to remember, although it is generally forgotten, when speaking of his ideas, of the evolutionary process of life. In his natural philosophy conceptions there was hidden a large grain of scientifically precise understanding—concerning the biosphere and not the planet—which was, however, concealed in the mist of vague philosophical intuitions.

The living matter, existing in the biosphere at a given moment, will hardly exceed some tenths fractions of a percent by mass when quantitatively estimating the biosphere. In



Archive of the Vernadsky Institute of Analytical and Geological Chemistry of the Russian Academy of Sciences

Alexander Pavlovitch Vinogradov (1895-1975)

preparing the table of clarks of the biosphere, the recalculation of the mass of the living matter and its critical evaluation will be the task of our Laboratory.

The chief geological importance of these masses of substance embraced by life, that seem small when compared to the mass of the biosphere, is connected with their exclusively great energetic capacity.

This property of the living substance, having nothing equal to it in the substance of the planet, not only at the given moment, but also in the aspect of geological time, completely distinguishes it from any other earthly substance and makes the distinction between the living substance and the inert substance of the planet quite sharp, the more so that all the living is derived from the living. The connection between the living and the inert substance of the biosphere is indissoluble and material within the geological time—of the order of a milliard of years, and is maintained exclusively by the biogenic migration of atoms. Abiogenesis is not known in any form of its manifestation. Practically, the naturalist cannot overlook in his work this empirically precise deduction from a scientific observation of nature, even if he does not agree with it due to his religious or philosophically religious premises.

In the scientific work of the naturalist, of the observer of the living nature surrounding him—the biosphere—no doubt can ever arise as to what he has to do with—a living or an inert natural body. Their sharp and fundamental material energetic distinction, the gap separating them, so to say—is striking. It seems to me that now for the first time in the history of scientific thought, in the filterable virus we come across a phenomenon where we are as yet unable to decide with precision and certainty whether we have to do with manifestations of the living or of the inert nature, of the living or of the inert substance.

This question will be settled in the nearest future. It is in this that lies the profound and philosophical interest of the scientific work which is now carried on in this field.

But one solution or another, the picture of nature, which is now revealed before us in the field of geochemistry and biogeochemistry, will not be affected, just in the same way as the discovery of the decay of atoms, of the variability of their atomic weight, does not in any way invalidate the laws of chemistry.

IV

The whole work of the Laboratory is based on such a structure of the biosphere, on the existence of an impassable sharp, materially energetical boundary between the living and the inert substance.

It is necessary to dwell on this point, since it appears to me that in this question there is a vagueness of thought, which impedes scientific works.

We do not proceed here beyond exact empiric observation, the deductions from which are obligatory for the scientist and as a matter of fact for every one; it is on this observation that he not only can, but must, base his work. These deductions may possibly be explained differently, but in the form of empiric generalization they are to be taken into consideration in science, for an empiric generalization is neither a scientific theory, nor a scientific hypothesis, nor else a working hypothesis. This generalized expression of scientifically established facts is logically as obligatory as the scientific facts themselves—if it has been logically correctly formulated.

The sharp material energetic distinction of the living organisms in the biosphere—of the living substance of the biosphere—from any other substance of the biosphere penetrates the whole field of phenomena studied in biogeochemistry.

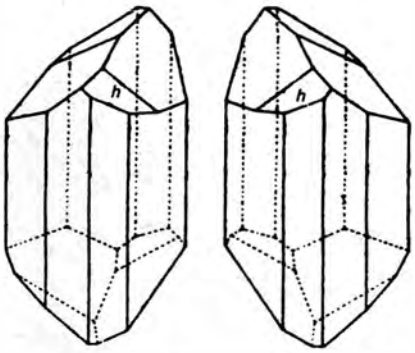
It is possible (this should be verified and investigated, but this study cannot be discarded, since it follows from the totality of biogeochemical facts) that among the phenomena characteristic and peculiar to living bodies alone, which sharply distinguish the living from the inert bodies, there is one phenomenon that is outstanding in its depth and significance, as well as in being little investigated; in the future, this field of researches may occupy a particular, dominating position in the work of our Laboratory, but as yet we can hardly approach it.

It was discovered over 70 years ago by L. Pasteur (who had predecessors, as for instance, Bechamp) and was not very suitably named by him "dissymmetry." Pasteur was the first to understand and express its fundamental meaning. He strongly emphasized it, but other problems diverted his attention from the work in this field. About 20 years later, the same phenomenon was taken up by P. Curie who died not only before having time to work his results, but even before being able finally to formulate them.

In his latest investigations he has defined these phenomena, as it seems to me, more deeply than Pasteur, pointing out the logical mistakes of the latter. Curie has pointed to the connection of dissymmetry with the thermodynamic and biochemical fields of life, with the volume of the organism, with the space occupied by it; he has indicated the spatial dissymetrical state of this space—the *state of space* in the biosphere, peculiar only to living beings.

From a painting by A. Edelfeld, 1889

Louis Pasteur (1822-1895). Pasteur's discovery of left and right-handed isomers of tartaric acid crystals led him to first express the meaning of dissymmetry.



PASTEUR'S SKETCHES OF LEFT-HANDED AND RIGHT-HANDED TARTRATE CRYSTALS

Vernadsky: "But in the sharp material and energetical distinction of the living substance in the biosphere from the dead, or inert matter, the phenomena of right- and left-sidedness hold so considerable a place, possibly a principal place, that in biogeochemistry we cannot overlook and pass them unnoticed."

A manifestation of Pasteur's dissymmetry and of Curie's peculiar "state of the space" of life is also found in the phenomenon of *right-sidedness* and *left-sidedness,* which has been known for thousands of years, but is only just beginning to be attacked by scientific thought. It has been up to now left outside the logical, mathematical, and philosophical analysis, although it is evidently connected with the deepest scientific problems.

In this respect it has shared, and shares, the destiny of the scope of reality, which corresponds to the conception of *symmetry,* within the boundaries of which operated the thought of both Pasteur and Curie. The experimenting physico-chemists are only just beginning to realize the significance of the theory of symmetry.

This insufficient logical, mathematical, and philosophical treatment of the phenomena of both symmetry and of right- and left-sidedness (dissymmetry) greatly hampers our work. But in the sharp material and energetical distinction of the living substance in the biosphere from the dead, or inert matter, the phenomena of right- and left-sidedness hold so considerable a place, possibly a principal place, that in biogeochemistry we cannot overlook and pass them unnoticed.

In phenomena embraced by the laws of symmetry, the dissymmetry is pronounced in the *inequality* of the quantitative and physico-chemical manifestations of right- and left-sidedness, the processes in these phenomena being *irreversible* since a dissymetrical space is characterized by polar vectors. They will express also the *time.* The *polar vector of time* characterizes just the irreversibility of the processes in time. In the inert nature, in its natural bodies—in crystals both natural and artificial—there is no inequality of right and left phenomena. In crystals, formed in the life processes, the inequality is most distinctly pronounced.

In the physico-chemical equilibria of our laboratories and in those in nature where life is absent, the right and left chemically similar components act similarly, as it follows from the laws of symmetry; they are chemically identical. In biochemical processes, going on, e.g., in the protoplasm, the inequality of the right and left component of the same racemic compound is most distinctly pronounced and may be both quantitatively and qualitatively traced to the end. In this field, in connection with our Laboratory, work has been started by Dr. G.F. Gause.

The study of dissymmetry is one of the current objects in the work of our Laboratory, but we shall be able to begin it only next year.

We cannot shut our eyes, however, to the fact that Pasteur was possibly right, when contemplating in the investigation of these phenomena a way towards the solution of the most important biological problems, and seeking in them the possibility of creation of life on our planet.

One point is doubtless. An analysis even of the present information, so incomplete and so far from perfect, shows that connected with dissymmetry are some of the principal

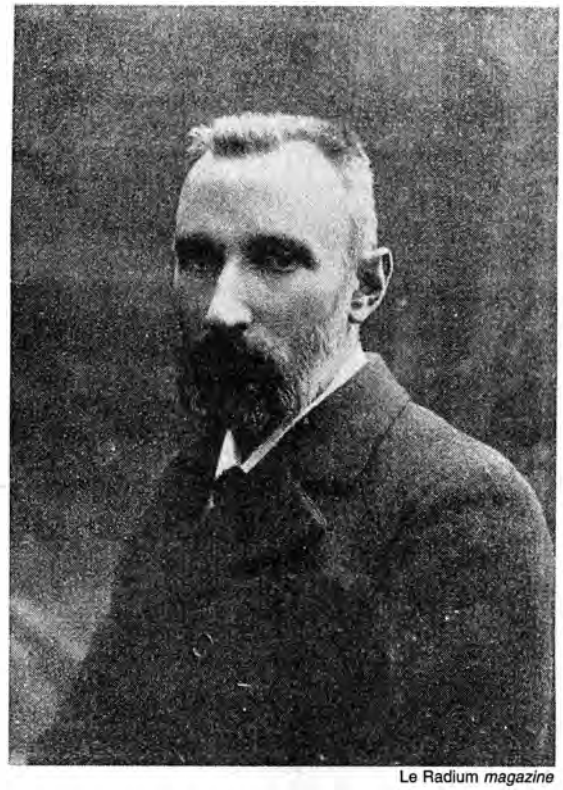
distinctions of the living from the dead, some of the fundamental manifestation of life in the biosphere.

The deeper proceeds our work, the clearer this is revealed.

It was clear already for Pasteur that dissymmetry in its manifestations may be produced only by a *cause having a similar dissymmetry;* but a logically deep deduction of this was made only by P. Curie; this inference may be expressed as a special logical principle determining the existence of life in the biosphere. It may be termed the *Pasteur-Curie principle,* and formulated as follows: *a dissymmetrical phenomenon is produced only by dissymmetrical cause.*

Hence it logically follows that the living in the biosphere will always originate only from the living; from dissymmetry, a logical inference maybe made of that great empiric generalization (1669) which I have named the *principle of Redi,* who was the first to advance it: *all the living is born from the living.* Another conclusion logically follows from dissymmetry, namely, that a dynamic equilibrium connected with life cannot be reduced in its physico-chemical consequence to reversible processes, since the time vector in a dissymmetrical state of the space is always polar.

There is still a third conclusion that may be logically reached, which is characteristic of the phenomena of life in the biosphere. It is as follows: In a limited definite region, distinctly separated from the rest of the planet, in a special shell of the Earth formed by the biosphere, which is characterized by irreversible processes—*life will increase* and not decrease in the course of time *the free energy of this shell.* This deduction, empirically observed, may be logically made from dissymmetry.



Le Radium *magazine*

Pierre Curie (1859-1906). Curie's study of the laws of symmetry led to his prediction and later discovery of the piezoelectric effect.

V

I shall not dwell here on a further analysis of the idea and significance of dissymmetry. I wanted only to call the attention of our scientific workers to the enormous significance of the dissymmetry phenomena so little attacked as yet by scientific thought. Our Laboratory will inevitably have to study these phenomena, and I am sure to be furnished with all the material means required.

It is, however, a great and difficult task—there is no wonder that it has not advanced during two or three generations. It calls for the cooperation of different specialists—of the physicist, biologist, biophysicist, physicochemist, and mathematician. It ought to be considered in the geological aspect.

It seems to me that I shall not take up your time in vain, when—with the same object of calling your attention to the neglected domain of knowledge which in my opinion is one of the greatest importance—briefly summarize those highly important phenomena which sharply and decisively distinguish the living matter in the biosphere from the lifeless matter, geologically long periods of time (no less than two or three milliard years). The connection between them exists only in the form of a biogenic migration of atoms.

These are:

(1) Dissymmetry.

(2) Abiogenesis connected with it: a living organism originates in the biosphere only from a living organism.

(3) Irreversibility of life phenomena connected with it.

(4) The accumulation of free energy as a result of the life process within the biosphere, connected with dissymmetry. The biosphere becomes more and more active in the course of the geological and historical time. I shall return to this phenomena some other time.

(5) The spreading of life in the biosphere goes on by way of reproduction which exercises a pressure on the surrounding medium and controls the biogenic migration of atoms. It is absent in the inert substance. The reproduction creates in the biosphere an accumulation of free energy which may be called *biogeochemical energy.* It can be precisely measured.

In our Laboratory we have not yet started a systematic work on the biogeochemical energy, since it is clear that this problem is a biological rather than a chemical one. It requires a special scientific organization, since the vast biological material concerning it has not been systematized nor collected, but is scattered, partly lost, and not used rationally. In the first place, all that is already known, must be brought to a form accessible for scientific work. It is necessary to prepare first a card-index continually operating and as complete as possible, on the reproduction of organisms and their spreading in the biosphere. The two problems are inseparable. They should comprise all the precisely established quantitative data available that are required for the derivation of the constants of biogeochemical energy. Shortly before moving to Moscow, the Laboratory approached the organization of such a card-index in Leningrad. At present we are carrying on negotiations with the biologists of Moscow concerning its organization here, in connection with the Laboratory, but separated from the latter. The card-index should be used both by us and

by biologists.

(6) Theoretically it is possible to derive the speed of spreading of every species of organisms in the biosphere, characteristic and constant for each species (the ν value). This speed is restricted within some limits, which are quantitatively determined by: (1) the dimensions of the biosphere, that is, of the planet in the long run, and (2) by the minimum dimensions of the organisms, connected with the Loschmidt's number, limiting the number of breathing organisms which can be present in a cubic centimeter of material space.

(7). The speed of spreading and reproduction is inversely proportional to the size of the organisms (generalization of A. Sniadecki, 1794). It attains its maximum value, ultimate under conditions of the biosphere. But life has a striking adaptability, and there can exist forms of life of an explosive nature, which are in a latent state during the greater part of their existence. These forms in the value of biochemical energy exceed the ν value, known for the usual manifestations of life.

Francesco Redi (1626-1698). Redi was the first to advance the principle that all the living is born from the living.

The whole biosphere is penetrated by life, embracing all its space. The spreading of life in the biosphere presents a full analogy with the spreading of gas in a limited space. Life, like gas, exercises pressure in the medium in which it penetrates.

(8) Every living organism has a certain autarchy; it actively selects from the surrounding medium the necessary chemical elements, may be, atoms. It is a biogeochemical and biochemical, but not a purely chemical reaction.

(9) Numerous other marked distinctions of a living substance from the inert matter of the biosphere may be noted. I cannot dwell on them at great length, but still I must say a few words on this subject, since it is concerned with a field of phenomena that have not attracted due attention on the part of naturalists. There is a marked difference in the rate of the biogenic migration of the chemical elements as compared with the migration of the elements of the inert matter of the biosphere. The biogenic migration is distinctly pronounced in a historically prolonged time; it takes place in the limiting cases with a speed of the order of the velocity of sound—the maximum possible movement in a material medium not connected with its destruction, with a permanent deformation of the medium itself.

The migration of chemical elements in an inert substance of biosphere proceeds at an exceptionally slow rate, and as a rule is manifested only in the duration of geological time, *for* which the relative duration of a hundred thousand years—a decamyriad—is not much greater than the duration of a second in the range of historical time. In a number of cases, for the bulk of the biosphere, not penetrated by life, the atoms are immobile, retaining their position for hundreds of millions—possibly up to two or three milliards years. A direct comparison of the composition of the natural objects, the living and the inert natural bodies, cannot be made without a correction for the velocity of spreading, for their biogeochemical energy. In the space time, in the volume occupied by a living organism, not only is the space in a particular dissymmetrical condition, but also time is manifested in a way different from that in which the time of the biosphere is manifested.

In the duration of geological time in the biosphere life manifests itself in the evolutionary process.

VI

Particular attention is to be paid to the presence of radioactive elements in living organisms. An investigation of these has been carried on at our Laboratory ever since the time of its foundation. We have established the constant contents in living organisms first of radium and then of its isotope—mesothorium I. It has been found that these elements are also characteristic—in their quantity—for every morphological and physiological expression of a living substance, for every taxonomic expression of such a substance, like other elements. This is, of course, quite comprehensible and could rouse no doubt, but in this case, due to the peculiar character of the decaying atoms—centers of radiation of an immense active energy produced by atomic concentration—a selective concentration of radioactive elements by living organisms—the investigation acquires a particular importance.

Evidently the organisms, in selecting radioactive elements, use the energy of the latter. It seems to me that this fact by itself is sufficient for an understanding of the importance of the connection between the phenomena of life and the structure of the biosphere.

The work of the Laboratory follows, on one hand, the line of collecting quantitatively expressed facts, and of increasing the number of radioactive elements investigated, on the other.

The Laboratory has proved not only the presence of a concentration of radium, but also of its isotope—mesothorium I. It has been for a year now that V.J. Baranov has been carrying on work concerned with the occurrence of actinium—a field as yet untouched by experiment and exceedingly difficult.

The investigations of our Laboratory have shown—on the basis of the considerations I have derived theoretically—the absence of usual thorium (with an accuracy within 1 percent) in the *Lemnae,* while the other isotope of thorium—radio thorium—invariably enters in the organism as a product of decay of mesothorium I.

This phenomenon enabled our radiologists to develop a

new method for uranium determination. The problem of uranium and its occurrence in organisms, with its quantitative estimation, is now comprised in the plan of the work of the Laboratory.

It has been found possible to proceed deeper and to advance, using V.J. Baranov's method, the problem of the location of individual radioactive atoms in a living organism, in the cells, and of their connections with the morphology of the cell.

The investigation should give a clear picture not only of the concentration of radioactive elements, but also of a quantitative estimation of the heat energy received by a given living organism and the nature of its utilization by the organsim—in connection with its biological characteristics.

The results already obtained clearly show that the way we have chosen to follow is the right one.

Some technical difficulties have delayed the progress of our work for a whole year, but this is only a temporary delay.

VII

Among the other investigations of the Laboratory, that are of a more particular nature, I have to mention the work connected with the biogeochemical role of silicium and aluminium. The fact is that in the scientific material up to now collected there are no precise data that could serve for elucidating the biogeochemical process which is responsible for the accumulation of great masses of biogenic silicium—and probably aluminium—minerals. We know only that both at the present time and in the geological epochs of the past there exist and existed organisms siliceous and rich in silicium, and aluminous and rich in aluminium.

The biogenic migration of these elements is undoubtedly of an exceedingly great importance, since these two elements are predominant in the biosphere. The course of their migration may be said to have been only just suggested.

Due to the particular significance of these processes, which must play an exceptional part in the biosphere, and after a number of fruitless attempts to organize their study elsewhere, I have begun the investigation of one of them in our Laboratory—namely, the decomposition of kaolin clays, of the kaolin complex ($Al_2Si_2O_7$), by the diatomaceous and bacteria. The investigations have been successfully carried on for a year by A.P. Vinogradov and E. A Boychenko.

It seems that the weathering of alumosilicates in nature—in soils—is connected with unicellular vegetable organisms and constitutes a part of a great process which is of a paramount importance for the vegetable cover of the Earth and for the geochemistry of the sea, where the free atoms of silicium, produced during the biogenic decomposition of the alumosiliceous complex, are collected in the algae.

In the recent years, more and more facts are collected which reveal the great part of the alumosiliceous complexes—of free alumosiliceous acids and oxyacids—in the soils and in the nutrition of plants. There is much evidence in favor of these bodies being formed in a biogenic way in the soils and presenting a characteristic feature of their chemistry.

I have no possibility to extend the scope of this investigation in our Laboratory. It remains for the pedologists or geochemists to carry this study to the end.

It seems to me that this investigation is now particularly timely in pedology. Sooner or later, it shall be started.

VIII

The study of the biogenic migration of the atoms of the living substance is the fundamental task of biogeochemistry. In spite of the fact that the mass of all living organisms is negligible when compared to the biosphere, since it is of the order of some tenth fractions of a percent—as a matter of fact, the living substance determines the whole chemical structure of the biosphere.

In the long run it leads to the creation of a considerable part of the substance of the biosphere; we do not know precisely how large it is, but it seems to be much in excess of one quarter of its mass.

In this biogenic mass we see marked differences distinguishing it from the remaining, inert matter of the biosphere.

Two forms of biogenic substance should be here distinguished: first, the one which is the final product of decay of a living substance—of its decomposition to simple fundamental compounds. Here belong the gaseous products of breathing and of biogenic metabolism CO_2, H_2, CH_4, N_2, H_2O, H_2S. The living substance, by way of a complicated process, passes to the final products of a simple composition, such as the above gases, or to solids and remains of skeletons—opals, carbonates, iron ores, phosphorites. They do not always bear traces of their biogenic origin. This is a return to inorganic bodies, partly original for the living substance; this is the completion of the cycle. It should be noted, that the Earth's gases which we generally encounter in the biosphere, in the form of vadose products, are the same as are created by the processes of life in the way indicated. Direct observations and calculations show that the atmosphere of our planet, the gaseous part of the planet, is in the overwhelmingly greater part a product of life. One may speak of the biogenic origin of the troposphere, for O_2, H_2O, N_2, CO_2. But the whole regime of the gases of the biosphere, of its underground atmospheres, where CO_2, H_2O, hydrocarbons play a prominent part, are genetically related to life.

From these biogenic minerals—gases and last inorganic rests—those products of dying, of the extinction of life, should be distinguished carbonaceons bodies in a solid or liquid state—great agglomerations of petroleum, coal, asphalt, humus—biogenic minerals. They play a conspicuous part in our civilization and with them, to a considerable extent, a new form of biogenic migration of elements is developed—the one created by human technics. Technics acts in the same direction, finally converting these products of life—of biochemical and biogeochemical reactions—to simplex compounds, finally to gases and inorganic rests partly creating new intermediate biogenic forms of matter. The laws of the technical biogenic migration of the elements, of the activity of *Homo sapiens,* are the same as for the other forms of biogenic migration.

The organic biogenic minerals are markedly different

Pacific Northwest National Laboratories

Shewanella, an iron-reducing bacterium, is found to fractionate iron (Fe) isotopes, selectively concentrating Fe-56 over Fe-54. As the sensitivity of modern techniques has increased, the existence of such fractionation by living processes has become amply illustrated.

from the minerals, composing the inert skeleton of the biosphere. We may always make sure of their particular state and can always distinguish them from the other minerals of the biosphere.

They have such features that distinguish them from the other inert matter of the biosphere which in some part possibly might have never been alive. They *have been living,* and this is seen both in their material composition and in definite biogeochemical manifestations, in the first place in their composition.

Due to the vast scale of biogenic migration, the composition of the living organisms is markedly different from that of the natural products of the inert matter of the biosphere. It is distinguished by the number of building compounds, amounting to hundreds of thousands or even to millions. The only number of species of insects probably approaches 10 million, of which about 800,000 are known at present. In every species there is a large number of its special chemical compounds. This variety of chemical structures is the manifestation of a special biochemical and biogeochemical energy of the living organism, of the biogenic migration of its atoms in the biosphere, proceeding in range of historical time, in seconds. For the minerals, leaving aside those of carbon (rightly considered by C. Harichkoff as a special part of the mineralog—mineralogy of carbon), but taking into consideration natural waters, over four- or five-thousand species may be expected. This number increases if we take into account the carbonaceous dead remains of organisms. Death abruptly interrupts the existence of an endless number of compounds. And still, the carbonaceous organogene minerals being fully deciphered should exceed (probably even several times) all the other minerals—the natural bodies of inert substance.

At the present moment of the history of biological sciences more important for us is another property of carbon, the manifestation of dissymmetry, the presence of traces of former life in the form of manifestations of inequality of right and left phenomena. Thus, the petroleums contain in a prevailing amount right isomers—their mixture, separated from their left isomers by the living process. The same is observed in humus, peats, and coals. The methods, indicated by L. Royer, enable us to establish it not by rotating the plane polarization of light as it is done for petroleums, but by rotating of the etching figures of crystals. And here right hand rotation seems to predominate. This work in a preliminary way has been begun at our Laboratory, but this year it has been postponed. We shall, however, resume it at the nearest opportunity, for connected with it are the principal questions of the biogeochemistry of carbon. It is probable that all the atoms of carbon, which are present in the biosphere, have passed during the geological time, during the milliards years of the existence of the biosphere, through the living substance.

For asphalts, however, this question cannot be considered as settled, The connection of some of them with V and Hg requires an investigation. The problem may be solved with the aid of etching figures. I have attempted to elucidate in my paper the significance and the interest of the new way which has brought us to the organization of the Biogeochemical Laboratory.

I am fully convinced, that in this field even the fundamental problems which will be opened before us, cannot be foreseen at present. Many problems in biogeochemistry, advanced in the recent years, have already attracted attention, and new facts, the basis of our knowledge, are rapidly collected in the course of work conducted not only within this country.

Moscow, 1936

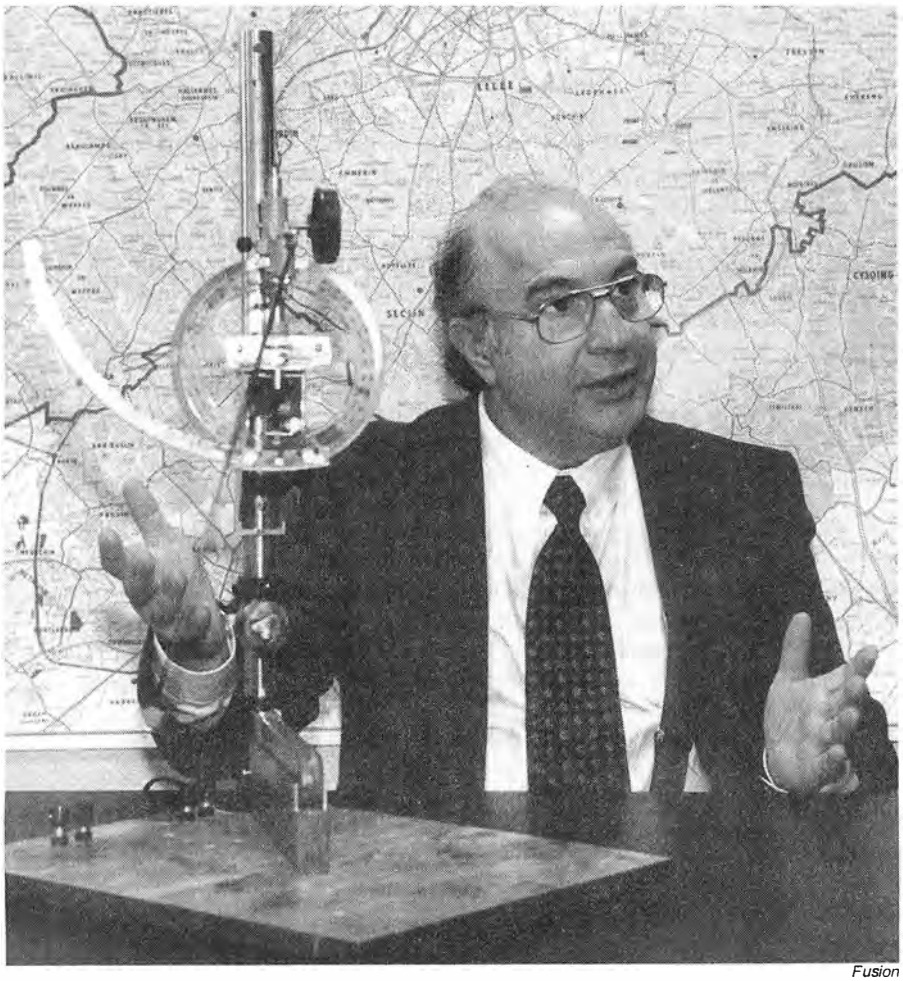
Editor's Note

1. This manuscript is from the archives of the Columbia University Library. It was published in Russian in *Izvestiiakh Geologicheskoi Gruppy* AN, CCCP (Bulletin of the Geological Group, USSR Academy of Sciences), 1938.

A translation of Vernadsky's "Problems of Biogeochemistry II: On the Fundamental Material-Energetic Difference between Living and Nonliving Natural Bodies in the Biosphere," (1938) appeared in the Winter 2000-2001 issue of *21st Century.* A translation of Vernadsky's 1943 paper, *"Some Words About the Noösphere"* appeared in the Spring 2005 issue of *21st Century.*

For a brief biography of Vernadsky, see "Vladimir Ivanovich Vernadsky (1863-1945): Pioneer of the Biosphere" by George B. Kauffman, *21st Century,* Winter 2000-2001.

Amplitude Quantization As an Elementary Property of Macroscopic Vibrating Systems



Fusion

Danil Doubochinski with his pendulum.

The discovery of a new physical principle, argumental oscillations, pokes holes in textbook physics and emphasizes the need to break out of the shackles of formal mathematics and of Newtonianism in general.

by Jonathan Tennenbaum

One of the strong points of physics and engineering in the Soviet Union was the study of what are sometimes called "nonlinear oscillations." A great number of important experimental and theoretical results emerged, of which only a part became generally known in the West.

Virtually unnoticed in the West, was the discovery of the phenomenon of quantization of amplitudes in certain macroscopic oscillating systems. This phenomenon, and the principle behind it, were originally discovered in 1968-1969 by Danil Doubochinski and his brother Yakov, while students at Moscow University. Subsequently, a number of leading laboratories in the Soviet Union carried out extensive theoretical and experimental investigations of the phenomenon, establishing the existence of a new class of vibratory processes—so-called "argumental oscillations"—and of a new technological principle, having an enormous scope of potential applications. Most of them derive from the ability of argumental oscillations, to efficiently couple together oscillational processes at frequencies differing by two or more orders of magnitude. For a variety of reasons, however, only a very few applications were brought to full fruition in the Soviet period; and those that were, remained in a limited domain that escaped broad notice in the international community.

In the meantime, Danil Doubochinski, now

working in Paris, has called attention to the fundamental importance of his discovery as a kind of bridge between so-called classical and quantum physics. It provides, in his view, an answer to a central question which Planck, Einstein, Schrödinger and others had posed at the beginning of the 20th Century, but were unable to answer in a satisfactory way: the question of the physical origin and nature of the apparent discontinuities—the so-called "quantum jumps"—in the interaction between atoms of matter and the electromagnetic field.

At the same time, Danil Doubochinski and a group of collaborators in France have succeeded in developing several specific technologies, based on the principle of argumental oscillations, to the point of ripeness for commercial application. These include an extremely efficient means for the atomization and vaporization of liquids by means of "resonant cavitation" and, on that basis, a revolutionary new technology for industrial refrigeration, having enormous potential economic benefits. Other near-term applications include low-cost production of drinking water and a highly efficient vibratory process for the preparation of emulsions. Beyond this, there remains a broad field of potential applications to such areas as the generation and transmission of electrical power, electrical motors and propulsion systems of a new type, radio frequency and microwave technologies, vibrational methods for processing of liquid and solid materials, new approaches to nuclear fusion, and more.

The author had the occasion to meet several times with Danil Doubochinski, to discuss his work and to witness some very beautiful experimental demonstrations of the quantization effect. One of them—a pendulum interacting with an alternating magnetic field—is so simple, that it belongs in every high school physics classroom.

An initial report on Doubochinski's work was published in March 2001 in the French-language magazine *Fusion*. The subsequent technological developments, and a growing appreciation of the pedagogical and scientific value of the work, justify the publication here of a revised form of the original report, including a more adequate discussion of argumental oscillations and the genesis of the discovery. We plan to follow this soon with a second article, covering some of the ongoing work on technological applications.

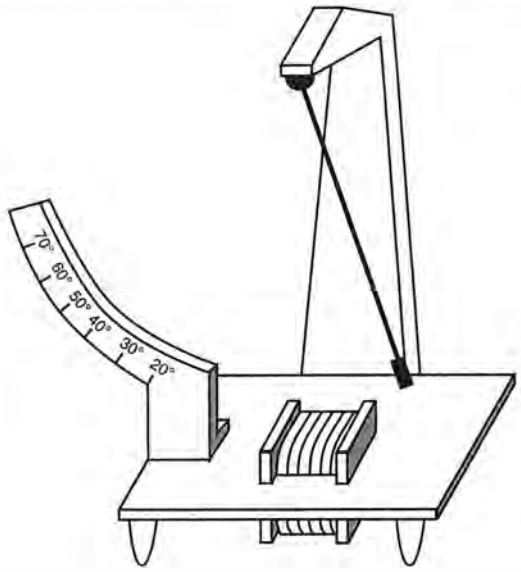


Figure 1
SCHEMATIC OF THE DOUBOCHINSKI PENDULUM

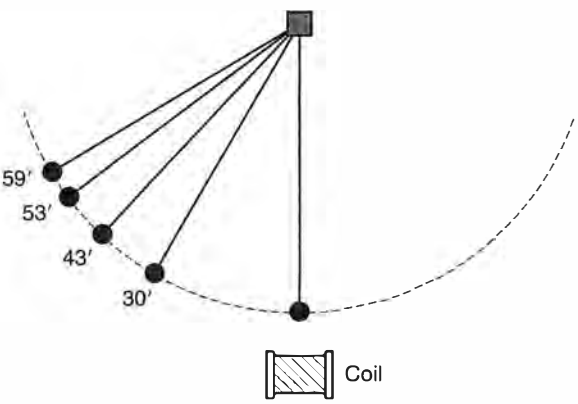


Figure 2
FIRST FOUR QUANTIZED AMPLITUDES
The four first quantized amplitudes of the Doubochinski pendulum, with a magnetic field frequency F = *50 Hz.*

Doubochinski's Pendulum

The pendulum (Figure 1) consists of a rigid arm on a low-friction pivot, constrained thereby to move in a horizontal plane, with a small permanent magnet fixed at its free end. An electromagnet is installed just under the lowest point of the pendulum's motion—the vertical position of the pendulum—with its axis aligned horizontally in the plane of the pendulum's motion, in such a way, that at any moment the electromagnet exerts an accelerating or decelerating action on the permanent magnet at the end of the pendulum, depending on the polarity of the current supplied to the electromagnet and on the direction of the pendulum's motion. The axis-length of the electromagnet is chosen short, relative to the length of the pendulum, so that the action of the electromagnet on the pendulum becomes significant only over a small portion of the pendulum's motion, when the end of the pendulum is located within a relatively narrow zone of interaction corresponding approximately to the length of the electromagnet. This spatial inhomogeneity of the field, acting upon the pendulum, plays a key role in the genesis of amplitude quantization.

Now we connect the electromagnet with a source of sinusoidal alternating current, whose frequency *f* and voltage can be varied over a wide range (typically f = 20 to 3,000 Hz, for a pendulum with a natural period of about 0.5 sec). As soon as the current is sufficient for a significant interaction between the electromagnet and the pendulum to occur, we observe the following characteristic phenomena:

When released at any arbitrary starting position, the pendulum's motion evolves into one of a discrete set of stable oscillation modes, having sharply differing amplitudes, but approximately the same period of oscillation—close to the

pendulum's undisturbed period (Figure 2). In each such mode, the energy lost by friction in the pendulum's motion, is compensated by net power transfer from the oscillating magnetic field, in a self-regulating manner. The system's "choice" among the discrete set of stable modes, is determined by the initial conditions.

Doubochinski's pendulum has the further remarkable property, shared by argumental oscillations in general, that the "quantized" amplitudes, and the corresponding stable modes of the pendulum, do not change appreciably, when the strength of the "external force" (the alternating field, in this case) is varied over a wide range. The amplitudes are highly sensitive, however, to changes in the frequency of the applied forces. The higher the applied frequency, the larger the array of stable modes that become accessible to the pendulum. (See Table 1).

Exactly this sort of behavior—strikingly different from that displayed by the linear resonators of classical mechanics—is characteristic of quantum processes in the microscopic domain, as exemplified by the photoelectric effect and the absorption of electromagnetic radiation by atoms and molecules.[1]

The pendulum's quantized modes are remarkably stable with respect to vibration and changes in the system's frictional and other parameters; large disturbances can cause the pendulum to "jump" from one mode to another, imitating the "quantum jumps" of atomic physics.

The effect does not depend on any special details of design or on the specific materials used in the construction of the electromagnet and pendulum. The system just described, in fact, merely exemplifies an entire class of macroscopic oscillating systems exhibiting similar "quantized" behavior. Some of these are more difficult to realize technically, but are more natural, from a theoretical physics point of view. One of them is extremely close to the theoretically idealized case of "elementary oscillators" interacting with an electromagnetic field, used by Max Planck in his investigation of the law of blackbody radiation. One suspects that the historical development of quantum physics would have taken a different course, had Planck and his contemporaries been familiar with the sort of phenomena, demonstrated by Doubochinski's pendulum.

It is remarkable, that despite the considerable academic and public attention paid in recent decades to so-called "nonlinear dynamics," "self-organization," "chaos theory," "synergetics," "dissipative systems," and so forth, no one seems to have pointed out an example so simple, so elementary, and at the same time so fundamental, as that discovered by Doubochinski. This embarrassing circumstance is no doubt due to the fact, that the bulk of research and publication activity on "nonlinearity," has had more to do with mathematicians' games, than with the mastery of physical reality. A more profound reason, we consider, is a lack of comprehension of the true, ontological meaning of nonlinearity. A truly nonlinear process is one, that by its very nature cannot be represented in a consistent and comprehensive manner by formal-mathematical methods.

F (Hz)	Pendulum amplitudes							
5				68°				
20	30°			59°		74°		85°
50	30°	43°	53°	59°	68°	74°	80°	85°

Table 1
THE STABLE QUANTIZED AMPLITUDES OF THE DOUBOCHINSKI PENDULUM AS A FUNCTION OF THE FREQUENCY OF THE MAGNETIC FIELD
The experimentally observed stable frequencies do not depend significantly upon the dimensions of the interaction zone (size of the coil), as long as the width of the zone remains small relative to the length of the pendulum.

Beyond 'Classical Mechanics'

At first glance, the processes studied by Doubochinski would appear to fall entirely inside the domain of classical (macroscopic) mechanics. Examining Doubochinski's pendulum, for example, any trained physicist or engineer can easily write down a rather simple differential equation to describe its motion, applying the standard Lagrangian method for an appropriate choice of mathematical function describing the external force acting on the pendulum as a function of the time and space coordinates (See box, p. 54). For this reason, some might dismiss Doubochinski's work as a mere exercise, having no fundamental interest.

The situation is rather more subtle than it appears, however.

First, from a purely technical standpoint, our physicist or engineer will note that the differential equation, describing Doubochinski's pendulum according to classical mechanics, is of a type that cannot be solved, in explicit form, by any of the presently known methods of mathematical analysis. Furthermore, the quantized amplitudes, observed in actual physical experiments, do not manifest themselves in the usual sorts of computer-based numerical-approximation solutions (simulations) of the differential equation.[2]

Second, apart from the mathematical difficulties it introduces, the spatial inhomogeneity of the force-field in Doubochinski's pendulum (and systems of a similar type) means that the external force, experienced by the moving pendulum at any moment, depends not only on the time, but also on the momentary position of the pendulum itself. This dependence of the external force on position, which is notably absent in classical textbook discussions of so-called "forced oscillations," permits the pendulum, in a certain sense, to self-regulate its exchange of energy with the external source. This condition is key to the quantized behavior, demonstrated by Doubochinski's pendulum. He employs the technical term "argumental oscillations" to describe the general case, in which the momentary position or configuration of an oscillating system, enters as a variable into the functional expression for the external, oscillating force acting upon it. The possibility of self-regulation of energy-exchange is a general characteristic of argumental oscillations.

Third: Although Danil Doubochinski and his collaborators have developed mathematical methods for the analysis of amplitude quantization and other properties of argumental oscillations, those who are looking for a mathematical deduction of the phenomena from the "laws of classical mechanics," will be frustrated. Doubochinski's theoretical-mathematical analysis lacks the quality of logical completeness, which typi-

fies the treatment of linear oscillators, for example, in textbooks of analytical mechanics. Accordingly, some critics regard his analysis of amplitude quantization as untrustworthy and even erroneous.

In fact, if we did not know, by direct experimental demonstration, that the phenomenon of amplitude quantification actually exists, then we would probably not be convinced by the analytical arguments that Doubochinski et al. have put forward on this account. But those arguments—which we shall briefly examine later in this article—were never intended to be a self-contained, aprioristic mathematical theory. They reflect on years of experimental investigations of real-life oscillating systems, and are intended to supplement—but not to replace!—those experimental results.

Far from claiming to deduce the behavior of his pendulum from "the laws of classical physics," Doubochinski sees in this behavior the manifestation of a new physical principle, which is not incorporated in classical physics as commonly understood. This point has given rise to considerable confusion, and necessitates a brief excursion into the issue of methodology, before we take a closer look at argumental oscillations.

Kepler vs. Lagrangian 'Virtual Reality'

Over the last 200 years, the influence of Lagrange's *Mechanique analytique* on prevailing modes of scientific education, has given rise to the widespread presumption, that so-called "classical mechanics" constitutes the perfect exemplar of a completed physical theory. It is presumed, that from the standpoint of physical principle, nothing fundamentally new could remain to be discovered in that domain. Danil Doubochinski disagrees.

Strictly speaking, of course, Planck's discovery of the quantum of action, and the subsequent elaboration of the so-called wave mechanics by Schrödinger, already imply a fundamental correction of classical mechanics. The standard textbook accounts assure us, however, that this correction, while significant in the domain of microscopic physical objects, can be virtually neglected when dealing with systems of macroscopic bodies. The reason given for this, is the practically infinitesimally small value of Planck's quantum, compared to the magnitudes of action involved in the motion of macroscopic bodies. The latter would include Doubochinski's pendulum and all other macroscopic systems belonging to the traditional domain of classical mechanics.

Physicists and engineers, who for generations have been drilled in the mathematical formalisms of Lagrange and Hamilton, often regard it as self-evident, that a macroscopic mechanical system is in principle fully equivalent to the corresponding set of differential or integral equations derived according to the Lagrangian or Hamiltonian methods of analytical mechanics. Many would hasten to add, of course, that in practice certain idealizations, simplifications, and approximations are always introduced, in order to make the mathematical equations more manageable. But this practice is purely pragmatic, and does not contradict the assumed, principled equivalence between the physical and mathematical systems.

Recent times have seen this view carried to the extreme, as some people have suggested that physics as a whole is already practically complete in terms of its foundations. The "fundamental forces" being essentially already known, all that remains is to solve the equations! This view has already found its expression in the growing tendency, in the teaching of physics and even in experimental physics itself, to replace actual experiments by computer-based "virtual experiments." The next step might be "virtual laboratories" staffed with "virtual scientists"!

However, the closely related trend toward use of large-scale computer simulations, to replace the costly and time-consuming practice of building and testing actual prototype systems, has led to some rather unpleasant consequences. The dangerous dynamic instability of Mercedes-Benz's famous computer-designed and computer-tested "A-Class" automobile, was revealed in 1997, when it repeatedly tipped over during independent driving tests, conducted after the car had already gone into production. Similarly, during the late-1990s the United States suffered a long series of catastrophic failures in the launches of computer-tested rocket systems, plus the total failure of two NASA Mars missions, which had functioned well in virtual reality simulations. Many more examples could be given.

The disasters caused by overreliance on computer simulations come as no big surprise to old timers in industrial science and engineering—people who know, from long and sometimes painful experience, the difference between the real-life behavior of physical systems and the virtual reality of textbook analytical mechanics.

The problem is not simply one of numerical accuracy, but a qualitative one: The mathematical methods of physics, while useful and indispensable in the hands of an experienced physicist or engineer, are by their very nature incapable of representing physical reality *per se*. The successful practice of technology always depends on the unique powers of the human mind, to conceptualize a physical process as a whole in terms of its underlying principles, and to correct for the errors that would inevitably flow from any blind use of formal mathematical and related methods. These are the same creative powers, which permit original scientists to uncover anomalies in areas thought to be completely understood by generally accepted scientific theory, and to discover new physical principles, not accounted for by existing, formal scientific knowledge.

Exactly this point was at the center of a very relevant struggle over the future of science in France two centuries ago, between the Republican circles associated with Monge, Carnot, Ampère, Arago, and Fresnel on the one side, and the oligarchic forces represented by Laplace, Cauchy, and others on the other. Unfortunately, Laplace and his backers were largely successful in their campaign to replace the original emphasis on physical geometry in the curriculum of the famous Ecole Polytechnique, by a curriculum centered on analytical mechanics in its most abstract form, including especially the Newtonian-Laplacian "celestial mechanics."

The politically backed imposition of Laplace's celestial mechanics as the supposed standard for mathematical physics, had nothing to do with its scientific merits. On the contrary: The utter failure of celestial mechanics to account for the most crucial feature of our solar system—the quantization of the planetary orbits according to harmonic principles, demonstrated by Johannes Kepler two centuries before—shows that

the Newton-Laplace form of mathematical physics is intrinsically flawed and does not correspond to reality.

Here we meet Danil Doubochinski again. He sees the quantization of orbits in the solar system, as an astronomical manifestation of the same amplitude quantization principle, demonstrated on the laboratory scale by his pendulum and related electromechanical devices. Doubochinski himself has made a preliminary attempt to account for the values of the planetary orbits on the hypothesis that they represent a form of argumental oscillations.[3]

Freeing the Mind from the Slavery of Newtonianism

More significant, for our present purposes, is the pedagogical value of Doubochinski's pendulum, not least of all in connection with a critique of the Newtonian conception of force, which has sown deep-seated prejudices not only in the minds of physicists, but within culture as a whole. Danil Doubochinski himself justifiably blames Newton, and later Lagrange, for having introduced a fundamental fallacy into physics, relative to the original, far superior standpoint of Kepler. This involves at least three, subsumed conceptual flaws:

First, the present-day hegemonic conception of force, going back to Newton et al., implies the idea of a rigid, "slave-like" obeisance of a system to an external "applied force," which does not really exist, in that way, in Nature.

Second, the idea, that a "force" can act, without itself being changed or influenced by the system upon which it is acting. Newton's third law of action and reaction is not enough to remedy that flaw, because it assumes a simplistic form of point-to-point vectorial action, not existing in the real world.

The third, most essential fallacy lies in the attempt to break up the interactions of physical systems into a sum of supposedly elementary, point-to-point actions.

According to the author's standpoint—which he has assimilated from the study of Kepler and Leibniz—such "forces" as the gravitational pull the Earth appears to exert toward a rock, do not exist as isolated entities in the manner represented by Newtonian physics. "Forces" are merely effects derived from the unified, Keplerian physical geometry of the Universe. When we lift a rock from the Earth's surface, we are effectively doing work against the organization of the solar system as a whole, and not merely against a supposed, elementary gravitational force "emitted" by the Earth in isolation.

Similarly, the idea of an external force, while it may serve as a "useful fiction" (to quote an expression of Leibniz) for the treatment of certain problems in mechanics, should never be taken as more than that. An "external force" is a simplistic approximation, for what in reality is an interaction of physical systems—an interaction whose existence derives from the circumstance, that the interacting systems never existed as isolated entities in the first place, but only as subsystems of the Universe as a whole, as an organic totality.

These remarks, which could be elaborated much more, should help the reader to avoid falling into a number of confusions, which might otherwise arise from the paradoxical nature of Doubochinski's work. On the one hand, he employs tools of classical mechanics in his analysis of argumental oscillations; on the other hand, his entire approach, and the implications of amplitude quantization itself, imply a radical departure from concepts which have become almost self-evident in the academic teaching and practice of physics.

Historical Background

Danil Doubochinski emphasizes that argumental oscillations had already found wide application in the design of particle accelerators and electron tubes, as well as in investigations of so-called Fermi acceleration of cosmic rays, long before the Doubochinski brothers' original work in the late 1960s and 1970s.

Argumental oscillations had already appeared, around 1919, in the pioneering work of Barkhausen and Kurz on the generation of microwaves. They noted that oscillating electrons, interacting with the high frequency electromagnetic field in the tubes they had constructed, spontaneously organized themselves into "bunches," moving in equal phase with

Differential Equation for the Argumental Pendulum

The standard differential equation for a simple circular pendulum is

(1) $ml\ddot{\varphi} = -mg\sin\varphi$

where φ is the angular displacement of the pendulum from the vertical position and l is the length of the pendulum. The term $-mg\sin\phi$ represents the component of the force of gravity in the direction of the pendulum's motion. The equation is usually written:

$\ddot{\varphi} + \omega_0^2 \sin\varphi = 0$, where $\omega_0 = (g/l)^{1/2}$

For small oscillations, $\sin\varphi \approx \varphi$ and the solutions of the corresponding equation $\ddot{\varphi} + \omega_0^2\sin\varphi = 0$, are simple sinusoidal oscillations $\varphi = a\sin(\omega_0 t + b)$, of frequency $f_0 = \omega_0/2\pi$ (called the proper frequency of the pendulum).

Equation (1) does not take into account the effect of frictional dissipation of energy; to do so, we must introduce a term $-\beta\dot{\varphi}$ on the right side of equation (1), where β is a coefficient expressing the effect of friction. This leads to the equation

(2) $\ddot{\varphi} + \beta\dot{\varphi} + \omega_0^2\sin\varphi = 0$

In the case of Doubochinski's pendulum, we have in addition an oscillating external force which acts only when the pendulum is inside the "interaction zone." The force can be expressed as $A\epsilon(\varphi)\sin(vt)$, where $\epsilon(\varphi) = 1$ for $|\varphi| \leq \varphi_0$, $\epsilon(\varphi) = 0$ for $|\varphi| > \varphi_0$. $F = v/2\pi$ is the frequency of the external field; A is its amplitude.

This leads to the full equation for Doubochinski's pendulum:

$\ddot{\varphi} + \beta\dot{\varphi} + \omega_0^2\sin\varphi = A\epsilon(\varphi)\sin(vt)$

In the case of small oscillations, when the pendulum remains inside the interaction zone, the equation reduces to:

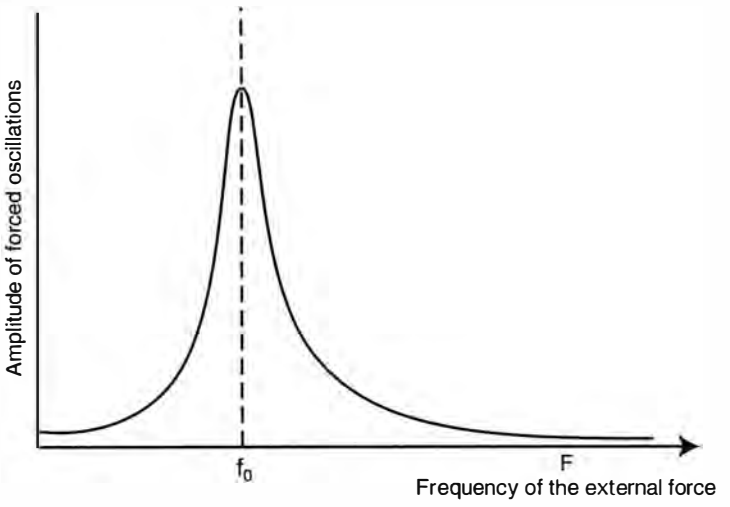
$\ddot{\varphi} + \beta\dot{\varphi} + \omega_0\varphi = A\sin(vt)$

which is the classical equation for forced oscillations of a damped harmonic oscillator. (See box, p. 55.)

respect to the field. This "bunching effect" is crucial to the efficient transfer of energy from the electrons to the field, and has been widely exploited in the technology of high-power microwave generation until now, as well as in high-energy particle accelerators.[4]

The self-organization of an originally continuous stream of electrons into discrete "packets" is a reflection, on the microscopic scale, of essentially the same principle that causes the quantization of amplitudes in Doubochinski's pendulum. But until the work of Doubochinski and his collaborators, no one had demonstrated the corresponding phenomena of argumental oscillations in macroscopic systems on the laboratory scale, nor called attention to the universal nature and potentially revolutionary technological implications of these phenomena.[5]

The experimental realization and detailed investigation of argumental oscillations in macroscopic electromechanical systems, was originally carried out by Danil and Jakov Doubochinski and J.D. Penner at the Physics Department of the Vladimir Pedagogical Institute in the early 1970s. These investigations were continued at the renowned Lebedev Institute in Moscow, and at other locations in the Soviet Union. In addition to the Doubochinski pendulum, which we shall now examine in some detail, various other devices were constructed on the principle of argumental oscillations, including new types of electric motors having a discrete multiplicity of rotor speeds for one and the same frequency of the supplied current.



TYPICAL RESONANCE CURVE FOR FORCED OSCILLATIONS OF A DAMPED OSCILLATOR

A strong resonance interaction is produced with an external force of frequency F only when F is near f_0, the natural frequency of the oscillator.

At the same time, it was realized that the phenomenon of amplitude quantification, although existing in reality, could not be demonstrated in standard large-scale computer simulations of the differential equations of motion. Specialized programs had to be developed *a posteriori*, to make certain aspects of argumental oscillations accessible to study with the aid of computers. Doubochinski has also developed mathematical methods for calculating the approximate values of the quantized amplitudes.

We now take a closer look at the pendulum, which provides the simplest and most striking experimental demonstration of amplitude quantization in argumental oscillations.

The Two Regimes of the Doubochinski Pendulum

To get a first insight, into why the behavior of Doubochinski's pendulum differs so radically from that expected from textbook physics, it is useful to contrast two regimes of operation of the pendulum, presenting two very different physical-geometrical characteristics: First, the case of small amplitudes, where the pendulum remains entirely within the interaction zone of the electromagnet; and second, the case of larger amplitudes, in which the pendulum moves beyond the interaction zone.

The first case corresponds very nearly to the textbook case of "forced oscillations of a linear oscillator under a periodic external force" (See box, this page). Imagine that we release the pendulum from a position well within the interaction zone, not far from the vertical. The magnetic field being approximately uniform in that zone, the accelerating or decelerating action of the electromagnet is essentially independent of the pendulum's position. For small amplitudes, the pendulum behaves very much like an ideal linear oscillator, reacting to the "external force" of the electromagnet.

The standard textbook analysis tell us, that when the frequency of the current supplied to the electromagnet is large compared to the frequency of oscillation of the pendulum, the net effect of the alternating field on the pendulum's motion will be small, and the evolution of the pendulum's amplitude will not change significantly from what would happen, if the electromagnet were not present at all. This, in fact, is the behavior we actually observe. Evidently, the effects of rapidly alternating acceleration and deceleration tend to cancel out over any given period of the pendulum.

The behavior of the pendulum in this regime of small oscillations, conforms broadly to the standard textbook accounts. A significant transfer of energy from the alternating field to the pendulum's motion occurs only when the frequency of the electromagnet's field comes close to the natural frequency of the pendulum itself. This is the classical case of resonant oscillations. Notably, the amplitude of the pendulum increases with the amplitude of the external force—in this case, as a function of the voltage of the alternating current supplied to the electromagnet—and can take on an apparently continuous range of values. There is no quantization on the macroscopic scale.

Doubochinski remarks, that in this classical form of resonance, the oscillator appears to be rigidly "enslaved" to the external force.

The behavior of the pendulum becomes much more interesting, however, as soon as the pendulum has sufficient energy to move beyond the narrow zone of interaction. Leaving

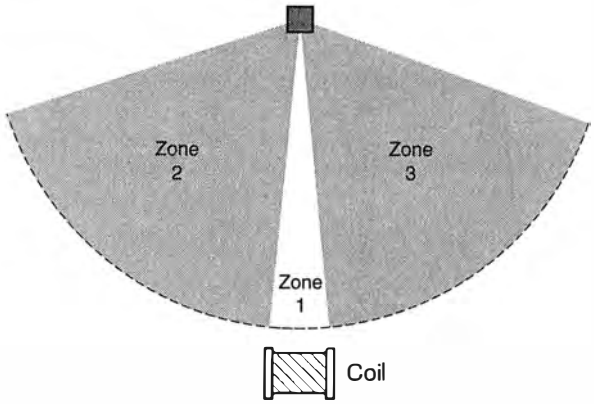


Figure 3
THE THREE ZONES OF MOVEMENT OF THE DOUBOCHINSKI PENDULUM
Zone 1 is the interaction zone; zones 2 and 3 are exterior zones.

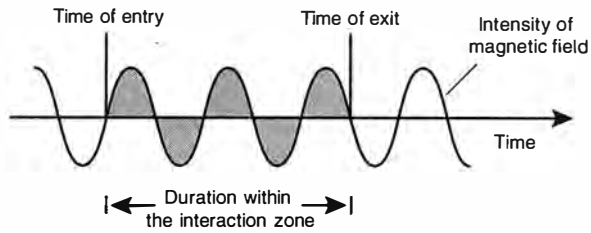


Figure 4
SINUSOIDAL FUNCTION OF THE MAGNETIC FIELD
Shown is the sinusoidal function of the magnetic field and included surface between the limits defined by the times of entry and exit from the interaction zone.

that zone, the action of the electromagnet on the pendulum drops off very rapidly toward zero, so the motion of the pendulum in the area outside the interaction zone is practically an undisturbed, free motion.

Thus, for large motions of the pendulum, we must distinguish among three different zones traversed by the pendulum (Figure 3): (1) the interaction zone and its immediate neighborhood, in which the alternating magnetic field exerts a significant influence on the pendulum; (2) the outer zone to the left of the electromagnet; and (3) the outer zone to the right of the electromagnet. In the latter two zones, the interaction between the magnetic field and the pendulum can be taken to be practically zero. The existence of these three zones implies—for the case of large motions—that the external force, acting upon the pendulum, is no longer independent of the pendulum's position, but depends on which of the zones the pendulum is located in at a given moment.

This circumstance fundamentally transforms the variety and character of the modes of exchange of energy between the pendulum and the alternating magnetic field. Most important, the process of "cancelling out" of alternating accelerations and decelerations of the pendulum by the alternating field in the interaction zone, is interrupted at the moment that the pendulum leaves the zone. If the alternating field completes a whole number of cycles during the time the pendulum traverses the zone, then the effects of positive and negative half-cycles will still cancel out; but if the number of cycles is not a whole number, then cancellation may not occur, and there can be a net transfer of energy between the pendulum and the field, during the former's passage through the interaction zone.

It is not hard to see, that the sign and absolute magnitude of the energy exchange, depend on the phases of the alternating field at the moment the pendulum enters and exits the interaction zone, relative to the direction of the pendulum's motion. For example, if the pendulum enters the interaction zone when the magnetic field is beginning a cycle, but leaves the zone in the middle of a succeeding cycle—that is, after an odd number of half-cycles—then there will be a non-zero, net transfer of energy (Figure 4). Assume the direction of motion of the pendulum, relative to the polarity of the field, is such that the initial half-cycle of the field has an accelerating effect. In this case, since the total number of decelerating half-cycles will be one less than the number of accelerating half-cycles, after cancellation of pairs of oppositely acting half-cycles, the net effect will be equivalent to that of the first half cycle.[6] In this case, the pendulum will gain energy. If the pendulum enters the field at the same phase of the current, but in the opposite direction of motion, the net effect will be a deceleration and a loss of energy.

Now, note that the exact relationship between entry and exit times depends not only on the entry velocity and direction, but also to a significant extent on the phase of entry. This is because the total "time of flight" through the interaction zone is modified by the changes in velocity caused by the alternating field. As a result, the amount of energy gain or loss during a single passage through the zone, is a complicated function of the entry velocity and entry phase.

Careful investigation shows that for a given entry velocity there always exist phases of entry, for which the pendulum enjoys a net increase in energy, as well as phases for which a net decrease occurs. The possibility of a net energy gain means that the pendulum—provided it can somehow "choose" the right phases of entry into the interaction zone—might be able to draw exactly as much power from the alternating field as it needs to overcome its frictional losses, and thereby maintain itself in a stable regime of motion.

The overall behavior of the pendulum will depend, however, on the cumulative effect of many successive passages through the interaction zone. The phases of entry into the zone can change from one entry to the next. Any attempt to foresee what will happen, from an *a priori,* mechanistic standpoint, leads us into a seemingly endless labyrinth of complexities, typical for what engineers and physicists broadly term "nonlinear problems." Given the lack of adequate, general theoretical principles for handling such problems, industrial engineering practice is obliged to resort, in each specific case, to an *ad hoc* combination of mathematical studies, computer simulations, and experiments, often expending large resources for this purpose.

Also in this case, the only reliable approach, at the outset, is

to actually build the pendulum and see what it does! A combination of hypothesis, experiment, and theoretical analysis allowed Doubochinski and his collaborators to identify certain crucial features of the process, connected with the emergence of a discrete, "quantized" array of stable amplitudes in the pendulum. These, in fact, apply to a much broader class of oscillating systems, subsumed under a common principle of "argumental interaction."

At the risk of taxing the reader's attention somewhat, we propose in the following paragraphs to go into the mentioned, crucial features of argumental oscillations in some depth. Full details of experiments and mathematical analyses are available in a large number of scientific publications from the Soviet period, most of which, however, are available only in the Russian-language original.

Velocity Modulation

The first observation we take up here, played a key role in the genesis of the Doubochinski brothers' original discovery.

If we assume, at the outset, that the period of the pendulum (at a given amplitude) is incommensurable with the period of the alternating current supplied to the electromagnet, then we should expect the phases of the field, at the moment the pendulum enters the interaction zone, to be randomly—that is uniformly—distributed among all possible values between 0 and 360 degrees. One might conclude, in that case, that the net result of the interaction, over many periods of the pendulum, would be essentially zero. Indeed, for each given phase of entry, the opposite polarity of the field (relative to the pendulum's direction of motion) would occur equally often, and, since the forces exerted on the pendulum, as a function of time, are exactly opposite for the opposite relative polarities, their effects would cancel out, on the average.

This reasoning, however, overlooks the possible effect, already mentioned above, of changes in the pendulum's net velocity, and thereby also in the time during which the pendulum remains in the interaction zone, as a result of the interaction with the electromagnet. As it turns out, that effect introduces a surprising asymmetry into the process, leading to a situation, in which the pendulum can draw a net positive power input from the electromagnet, even without a tight correlation of phase having been established.

The principle involved is illustrated by Figure 5. Here the sinusoidal curve represents the accelerating or decelerating force of the field generated by the electromagnet, relative to the motion of the pendulum; and the vertical line at left and the arrows at right plot the moments of entry and exit of the pendulum from the "interaction zone." Evidently, the net change of velocity of the pendulum, between entering and exiting the zone, will be equal to the integral of the accelerating/decelerating force acting on it in that zone; that is, the total area bounded by the curve between the entry and exit times, with the portions under the *x*-axis counted negatively.

Designate the width of the interaction zone by *d,* the velocity of the pendulum at the point it enters the interaction zone by v_0, and the period of oscillation of the current supplying the electromagnet by *T.* Thus, if the field were turned off, the pendulum would traverse the zone in a time t_0 equal to d/v_0. Assume that the field of the electromagnet is not too strong, so

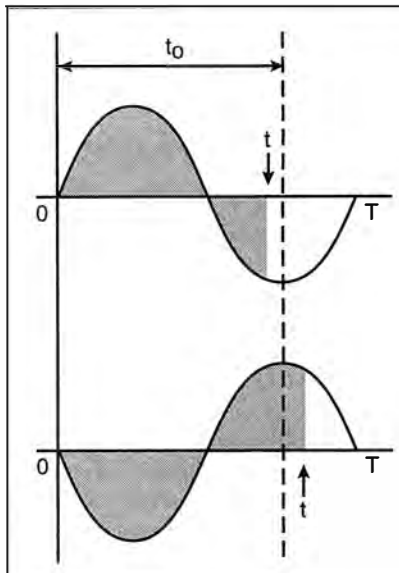


Figure 5
THE EFFECT OF VELOCITY MODULATION FOR OPPOSITE PHASES
Shown are the effects of velocity modulation for one pair of opposite phases. The arrows mark the moments of exit of the pendulum from the zone of interaction.

that the change in velocity of the pendulum, as a result of a single passage through the field of the electromagnetic interaction zone, is only a small fraction of its velocity v_0. This is the normal operating situation of Doubochinski's pendulum.

Now, consider different possible relationships between the "transit time" *t* and the period of the electromagnet. Evidently, if *t* is exactly equal to a whole period *T* of the electromagnet, then the effect of the positive and negative phases of the field would cancel out, and the pendulum would exit the interaction zone with the same velocity v_0, as when it entered.

For a larger velocity v_0 (larger amplitude), we will have $t < T$. Assume, for the sake of illustration, that $t_0 = 3/4T$. This is the situation presented in Figure 5. In the first diagram (a) we consider the case, where the pendulum enters the interaction zone at the very beginning of an accelerating phase of the electromagnet. Because the pendulum experiences a whole accelerating phase, but only part of a decelerating phase, the net effect will obviously be an acceleration of the pendulum. Compare this with the effect of the opposite phase (b), where the pendulum experiences a net deceleration. Now, if the time of interaction were the same in both cases, then the two effects would be equal and opposite. Observe, however, that in the first case (a), because of the net acceleration of the pendulum's velocity, the "transit time" *t* of the pendulum will no longer be equal to t_0, but will be slightly shorter, with a decelerating effect.

Similarly, in the second case, the net deceleration of the pendulum will cause it to stay in the interaction zone slightly longer than t_0. The result of this, as the reader can easily see, is that the areas under the two curves, from the moment of entry to the moment of exit from the zone, are no longer equal and opposite: The net accelerating effect (that is, net increase in the kinetic energy of the pendulum) in case (a) will be larger than the net decelerating effect in case (b). Taken together, the two would result in a net gain in energy by the pendulum.

What happens when the pendulum enters the interaction zone at a different phase of the alternating current than at the beginning of a cycle? A thorough analysis of all possible cases—which for brevity we omit here—shows that although

some phases yield a net acceleration, and others a net deceleration, the effect of velocity modulation is to produce an overall net gain in energy of the pendulum, when averaged over many randomly distributed phases.

An early paper, published in *Soviet Physics Uspekhi* in 1973, summarized the situation as follows:

> The assumption that oscillations maintained by a harmonic force always assume the frequency of this force or a multiple of this frequency is widely used in the theory and practice of mechanical oscillations. However, inertial, thermal, and other effects, frequently not taken into account, introduce time shifts between the driving force and the dynamic functions of the oscillations, and can lead to an asynchronous excitation of undamped oscillations. . . . When the frequency of the oscillating system is not commensurate with that of the alternating external force, a resultant positive energy contribution (averaged over a number of oscillations) is possible if the system alters the time of flight through the interaction zone sufficiently strongly.

In particular, these results imply the possibility for the oscillating system (the pendulum in our case), of drawing power from a much higher-frequency alternating field, to compensate its frictional losses, and even increase its amplitude in the course of many oscillations.

Estimates of the net average energy transfer to the system, showed that it can take alternately negative as well as positive values, depending on the relationship between the nominal transit time t_0 and the period of the alternating field T.

If, for example, t_0 is equal to $\frac{1}{4}T$, rather than $\frac{3}{4}T$, then one can easily convince oneself that the average effect will be net loss of energy by the pendulum, rather than a net gain. Since complete cycles of the field have no net effect on the velocity of the pendulum, the values $t_0 = \frac{1}{4}T + T, \frac{1}{4}T + 2T, \frac{1}{4}T + 3T$, and so on, and $t_0 = \frac{3}{4}T + T, \frac{3}{4}T + 2T, \frac{3}{4}T + 3T$, and so on, will yield the same sign of effect—that is, a net overall deceleration or net overall acceleration—as $t_0 = \frac{1}{4}T$ and $t_0 = \frac{3}{4}T$ respectively.

This difference in behavior, depending on the nominal transit time of the pendulum through the interaction zone—that is, on the velocity v_0, which in turn is a function of the pendulum's amplitude—already points to a potential mechanism for the selection or quantization of amplitudes: Amplitudes for which losses dominate, will be damped out, whereas those that can draw net energy from the source, can sustain themselves.

Phase Synchronization

However, detailed experimental studies of the Doubochinski pendulum, revealed a second, crucial phenomenon involved in the emergence of precisely determined, dis-

How to Build a Doubochinski Pendulum

The construction is very simple (see Figure 1). The oscillating mass consists of a short permanent magnet, with one of its poles pointing downward, attached to the end of a wooden rod (or other rigid arm) 30 to 60 cm in length. When crossing the position of equilibrium, the pendulum crosses over a flat-shaped electromagnet (solenoid) 9 to 12 mm in width, whose axis is parallel to the pendulum's motion. The solenoid is supplied with alternating current from the household net, through a resistive load or from a transformer.

The windings of the solenoid should run perpendicular to the pendulum's plane of oscillation. The solenoid itself is mounted symmetrically, relative to the equilibrium (the lowest) position of the pendulum.

For the best results, observe the following details in the construction of the argumental pendulum:

The form of the permanent magnet at the end of the pendulum should be square or rectangular (a flat shape is best). One can also use a magnet of irregular form, for example a fragment of dimensions approximately 8 × 10 × 10 mm, broken off from the ferrite magnet of a loudspeaker).

As stated above, the magnet should be mounted on the end of the pendulum arm in such a way, that one of its poles points vertically downward toward the solenoid when crossing over it. In fact, the effect can also be obtained with a horizontally positioned magnet; however, in this case, the values of the discrete amplitudes will be somewhat different from those corresponding to the vertical orientation. The permanent magnet can be directly glued to the rod or fastened to it with the help of strong adhesive tape. A suitable pendulum arm, with a cross-section of 3 × 5 mm, can be fashioned from the material of a wooden ruler.

The suspension of the pendulum must have low friction. This requirement can be fulfilled quite well by using suspension mechanisms taken from discarded electrical measurement devices, of the sort that have moving pointers, such as voltmeters, multimeters, and so on. Generally, any suspension can be used that permits motion in a fixed plane with very little damping of the oscillations. Fix the pendulum arm to the suspension using a thin brass or aluminum fastener.

The solenoid can be a rectangular coil of dimensions 10 × 30 × 100 mm, wound with insulated wire of diameter 0.15 mm. The number of windings in the coil should be about 800. The optimal voltage for routine operation of the pendulum, is around 70 V. However, in order to test the effect of differing field strengths on the behavior of the pendulum, one can introduce a rheostat into the power supply, allowing the voltage to be varied continuously from 10 to 200 V. In the higher voltage range, it may be necessary to keep the time of operation short, to avoid overheating of the coil.

This is based on an article by D.I. Penner, M.I. Korsakov, Danil Doubochinski, and Yakov Doubochinski, published in the Soviet journal Physics in School, *1981.*

crete amplitudes and the remarkable stability of the quantized modes: After the release of the pendulum from a given position, the phases of entry into the interaction zone soon cease to be distributed in a random manner. The pendulum adjusts its motion in such a way, that its entry into the zone becomes very nearly synchronized with a specific phase of the alternating field. This "auto-synchronization" of the pendulum is analogous to the effect of "phase bunching" of electrons or other charged particles in a high-frequency electromagnetic field, as mentioned earlier. Careful analysis shows that the auto-synchronization tendency of the pendulum is itself closely connected with the mechanism of velocity modulation, which we just examined. Let us now see, how that synchronization tendency in turn leads to a discrete series of amplitudes for the pendulum.

Observe, first, that the pendulum passes through the interaction zone twice for each full period—once in each direction. Between any two successive passages, the pendulum swings freely in the outside area, up to a certain maximum height, and then swings back to enter the interaction zone in the opposite direction. That process takes a certain time, between the moment the pendulum exits the interaction zone and the moment it reenters that zone. Consequently, the phase of the alternating field at the moment of each new entry into the interaction zone, depends on the phase at the moment of the preceding exit from that zone, and the time between those two moments.

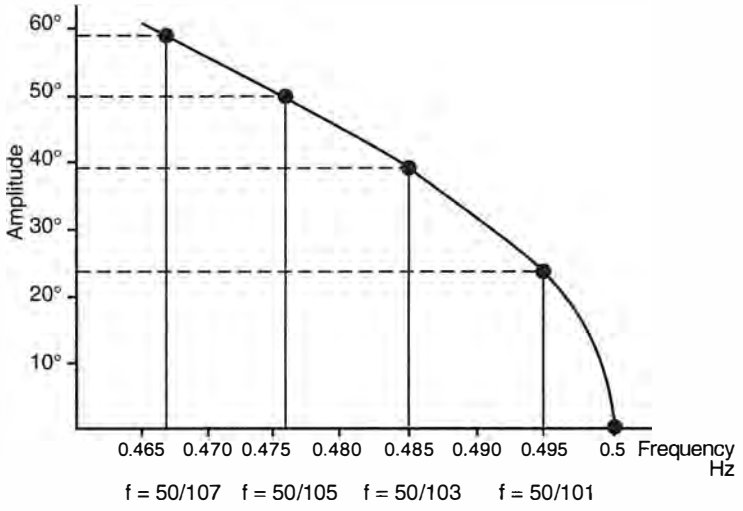


Figure 6
RELATIONSHIP OF AMPLITUDE TO FREQUENCY
The relationship of amplitude to frequency in a circular pendulum is shown. The approximate formula is $a \approx 162\sqrt{1-(f/f_0)^2}$, *where f is the frequency and* f_0 *is the natural frequency (small oscillations), which, in our example, is equal to 0.5 Hz.*

Next, take account of the important fact, that the elapsed time between successive exit and reentry into the interaction zone—and thus the relationship between the phases of successive entries into that zone—depends on the amplitude of the pendulum's motion. For larger amplitudes, the pendulum takes slightly longer to arrive from its maximum height to the interaction zone near the bottom of its swing. This fact is related to a property of a circular pendulum, which should be known to any student of classical physics and is commonly referred to as anisochronicity: The period of oscillation is not fixed, but depends on the amplitude of the pendulum's motion.[7]

The dependence of periodic time on the amplitude, opens up a new possibility for our system, which is entirely absent in the classical linear systems: namely, to use its variable amplitude as a means for regulating its phase relationships with respect to the alternating field.

It is also important to note, by the way, that even a nominally linear oscillator, when subjected to the velocity-modulating influence of a spatially inhomogeneous alternating field, can take on anisochronic characteristics that permit it, too, to regulate its phase relationships in similar manner to the Doubochinski pendulum.

Returning to the pendulum, let us suppose, to be concrete, that the alternating field has a frequency F = 50 Hz, and the pendulum's characteristic frequency (the frequency for very small amplitudes) is 0.5 Hz (a period of 2 seconds).

Figure 6 illustrates the dependency of the pendulum's momentary frequency on its amplitude, for a typical choice of physical parameters of the pendulum. Note, that for certain values of the amplitude, the frequency of the alternating field (50 Hz) will be an integral multiple of the frequency of the pendulum—that is, when the alternating field performs a whole number of oscillations during a single period of the pendulum. As a result, the phases of the alternating field, at which the pendulum enters and exits the interaction zone, will be repeated from one cycle of the pendulum's motion to the next, opening up the possibility of a stable, "stationary" regime.

The first case of this arises for "infinitesimally small" pendulum motions, whose frequency is f = 0.5 Hz. The ratio of frequencies is F/f = 50/0.5 = 100. In this case, however, the pendulum remains inside the interaction zone and behaves essentially as predicted by the classical theory of resonance: The frequency of the "external force" being many times larger than the characteristic frequency of the pendulum, there is practically no effect on pendulum's average motion, and there is no quantization of the amplitude.

For larger amplitudes, the period of oscillation of the pendulum will be slightly longer, and its frequency lower, leading to a larger value for the ratio F/f. The next whole-number value, larger than the value 100, would be F/f = 101, which would occur for a pendulum frequency of f = 50/101 Hz = approximately 0.495 Hz. Looking at Figure 6, we see that this corresponds to an amplitude, in terms of maximum angle of deflection from the vertical, of about 23 degrees.

In this case, the pendulum's motion goes beyond the bounds of the interaction zone; for each full period, it passes twice through-—once in each direction. The time between the

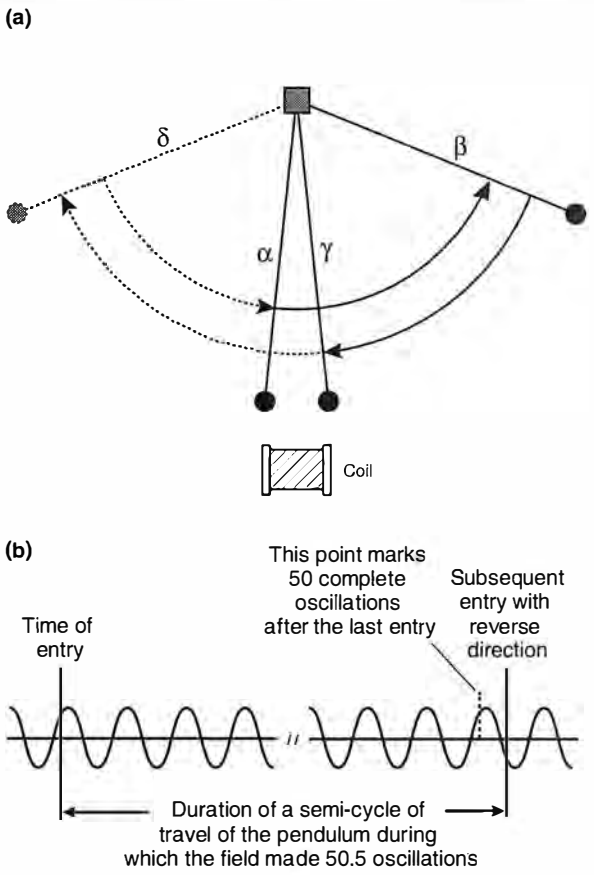


Figure 7
PHASE RELATIONS

Shown in (a) are half-cycle movements of the pendulum during two successive journeys through the interaction zone. The pendulum enters the zone at α, traverses the zone, reaches a maximum height at β, and enters the interaction zone in the inverse direction γ. During the next half-cycle, the pendulum goes from γ to δ, and from δ to α.

The oscillations of the sinusoidal function of the magnetic field during the two successive entries of the pendulum into the interaction zone are shown in (b), where one sees that the second entry is made with reverse phase (displaced by 90° in relation to the first entry).

moment of entry in one direction, and the next moment of entry in the opposite direction, corresponds to a half-period of the pendulum, which in turn corresponds to 101/2 = 50.5 oscillations of the alternating field (Figure 7). Thus, in the time between two successive passes through the interaction zone, the alternating field makes exactly a whole number of cycles plus a half-cycle. This means that the pendulum, when reentering the interaction zone after a given passage, will encounter the alternating field in a phase which is shifted by 180 degrees—that is, the opposite phase—relative to that of the previous passage. Since it is also moving in the opposite direction, the effect on the pendulum will be to accelerate (or decelerate) it by exactly the same amount as in the previous passage. In other words, the gain (or loss) in energy of the pendulum will be the same for both of the two successive passes through the interaction zone.

Ratio F/f	101	103	105	107	109	111
Observed amplitude	30°	43.2°	53.2°	59.9°	68°	74.2°
Calculated amplitude	22.8°	39.1°	50°	58.6°	65.9°	72.1°

Table 2
OBSERVED AND CALCULATED AMPLITUDES

Now, as we noted earlier, there will always exist phases of entry into the zone, for which the pendulum receives a net surplus (or net loss) of energy. If the friction in the pendulum is not too large, then a phase will exist for which the gain in a single passage through the interaction zone, exactly balances the frictional loss in a half-cycle of the pendulum. If we release the pendulum at the right amplitude (the approximately 23 degrees we determined above) and at the right moment (so it enters the interaction zone at the appropriate phase), then it will reenter the zone after a half-period in the opposite direction and in exactly the opposite phase, pick up the exact same energy gain, and reenter the zone once again in the correct phase after another half-cycle. We will thus have a so-called "stationary regime" in which the pendulum maintains a constant amplitude, drawing just as much power as it needs to overcome its frictional losses.

Several remarks are important to make at this point.

First, our discussion actually points to the potential existence not only of one, but of a discrete series of stationary regimes. The essential parameter is the ratio of frequency of the alternating field to the frequency of the pendulum. In our discussion above, we saw that a stationary regime is possible for $F/f = 101$. It is easy to see, however, that the same argument applies whenever the ratio F/f is equal to an odd whole number, that is, 103, 105, 107, and so on. For our chosen case of $F = 50$ Hz, these values correspond to $f = 50/103$ Hz $= 0.485$ Hz; $f = 50/105$ Hz $= 0.476$ Hz, $f = 50/107$ Hz $= 0.467$ Hz, and so on. Looking at Figure 6, we can read off the values of the pendulum's amplitude, which correspond to these frequencies.

Second, we did not take account, above, of the slight changes in the momentary relationship between amplitude and frequency of the pendulum, caused by the interaction with the electromagnet over a single half-cycle.

For these and other reasons, although our analysis strongly suggests the existence of "stationary regimes," it by no means proves that they can actually be realized in practice. For example, how does the pendulum "find" the suitable phases and amplitudes? In experiments, the pendulum actually demonstrates its ability to do this, but a truly comprehensive theoretical explanation has not been given.

Self-Regulation

In fact, the theoretical amplitudes, calculated above, do display a rough correspondence to the "quantized amplitudes" actually observed in experimental realizations of

Doubochinski's pendulum. The discrepancies, caused mainly by the effects of friction and the changes in velocity inside the zone of interaction, are largest for the smallest amplitude observed (typically 30 degrees, as opposed to the calculated 23 degrees).

On the other hand, the actual quantized motions realized in Doubochinski's pendulum do not correspond exactly to the ideal stationary motions described above, but are much more complicated. They agree only in average with the idealized motions. What occurs, in first approximation, is that the actual phases of entry into the interaction zone "wander" around the values corresponding to "pure" stationary motions.

These experimentally observed phenomena are best described in terms of the so-called "phase-space diagram" (Figure 8). When the system is disturbed, its phase-space trajectory begins to "orbit" around the motion corresponding to the stationary regime. If the disturbance is not too large, this "orbit" is gradually dampened out, and the system's phase-space trajectory is a spiral, converging toward a small "wandering" motion in the vicinity of the stationary regime. A major disturbance, however, can throw the pendulum into a completely different phase-space region. In some cases, the pendulum executes a "quantum jump" to a different quantized amplitude.

In fact, depending upon the initial conditions, even much more complex behavior is possible—for example a motion, which spontaneously jumps back and forth between quantized amplitudes, imitating the behavior of some atomic systems in quantum physics. Nevertheless, the stable, "quantized" amplitudes prevail as the "favorite" modes of Doubochinski's pendulum, and are by far the easiest to demonstrate.

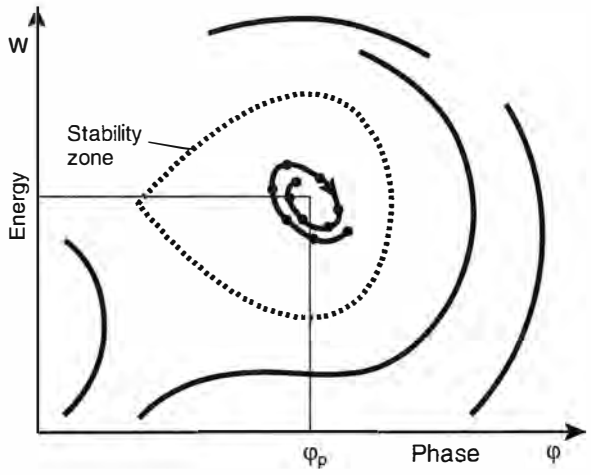


Figure 8
PHASE DIAGRAM OF PENDULUM TRAJECTORY
In this phase diagram, φ_p is the phase corresponding to a "stationary system."

Stability Properties

All of this would be little more than a scientific curiosity, of little practical import, were it not for the fact that the quantized regimes of the Doubochinski pendulum and other, suitably constructed argumental oscillators, display an extraordinary stability relative to both large variations in the strength of the driving force (that is, the current in the electromagnet), and to external perturbations of various kinds. Both these characteristics are crucial to the technological applications of argumental oscillations.

In experiments carried out by the Doubochinskis and their collaborators on the argumental pendulum, the voltage supplied to the electromagnet was varied over a wide range, starting with the lower limit at which the stable quantized oscillations appeared, up to a value nearly 20 times higher. The frequencies of the quantized regimes remained strictly constant, and amplitudes varied by less than 1 percent.

Precise observations revealed the mechanism of this remarkable adaptability, which holds true for argumental oscillations in general: It is by shifting the phase of entry into the interaction zone, while keeping the frequency and amplitude relatively constant, that the pendulum is able to maintain its "regime," compensating for changes in the strength of the source by modifying its interaction with the electromagnet. The same apparent "phase intelligence" of the pendulum, permits it to defend its quantized regimes—within certain limits, of course—against external disturbances of various kinds.

A general characteristic of argumental interactions between a high-frequency "source" and a low-frequency oscillator, is that the oscillator adapts to the "source" mainly by variations of phase, while its overall period of oscillation remains close to that corresponding to its own "proper frequency."

In this context, as demonstrated in countless experiments with a wide variety of mechanical, electromechanical, and electronic devices, the span of frequencies that can be efficiently coupled to each other in this way, can be enormous: For example, Doubochinski's pendulum, whose "natural" frequency is in the range of 0.5 Hz, can maintain itself in stable oscillations at nearly the same frequency, by drawing energy from a source (the electromagnet) operating at 1,000 Hz or more. With other devices, the frequency ratio can be even very much larger. As noted above, the spectrum of stable regimes is a function of the frequency applied to the system, and becomes richer and denser, the greater the ratio between the external frequency and the "natural" frequency of the oscillator.

These features open up the possibility of "feeding" a large number of oscillating systems, each at its own frequency, different from the others, by a single high-frequency source.

Finally, we should note, that the theoretical analysis of the stable motions, sketched above, depends quite essentially on two assumed properties of the oscillator (that is, the pendulum): (a) its anisochronicity, which allows the system to satisfy the condition F/f = an odd whole number, by adjusting the value of f; and (b) the existence of frictional dissipation, which appears essential to the stability of the quasi-stationary regimes. In reality, however, careful experiments have shown that the quantization phenomenon occurs even in the absence of these assumptions—a fact of physics not accounted for by the mathematical models. Once again we are confronted with evidence of a new physical principle.

Argumental Oscillations and Planck's Quantum of Action

As we noted earlier in this article, Doubochinski's pendulum is only a convenient pedagogical example of a very large

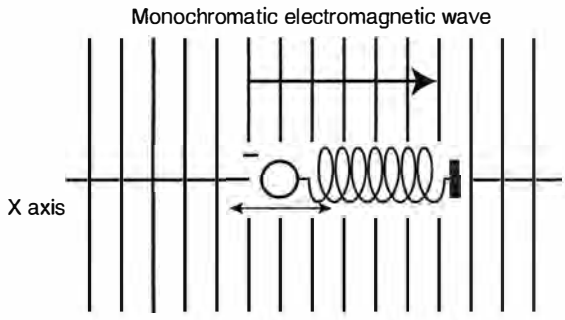


Figure 9
DIAGRAM OF THE DOUBOCHINSKI-PLANCK OSCILLATOR
The differential equation according to classical physics is $\ddot{x} + \beta\dot{x} + \omega_0^2 x = A \sin(vt - kx)$. $v = 2\pi F$; k = *wave number.*

class of oscillating systems, in which the strength of the "external force" depends on the momentary position (or configuration) of the system, and not only upon the time. More difficult to realize in a simple mechanical model, but more natural from a physical standpoint, is the case of a spatially extended oscillator—idealized here as a charged body fixed to a spring—interacting with a high-frequency electromagnetic field (Figure 9).

With one very important difference, this case closely resembles the picture of the "elementary oscillators" considered by Max Planck in his studies on so-called "blackbody radiation." Blackbody radiation was conceived hypothetically as the equilibrium radiation field resulting from the emission and absorption of electromagnetic radiation by a large number of atoms or molecules in a cavity with reflecting walls. Regarding the atoms in first approximation as an aggregate of "elementary electromagnetic oscillators," Planck counterposed the hypothetical spectral distribution of blackbody radiation as a function of temperature, predicted by calculations based on the commonly accepted, Maxwellian "laws of electrodynamics," to the completely different spectral characteristics actually observed in experiments. To account for this gross discrepancy, Planck hypothesized a new physical principle, referred to as the "elementary quantum of action," shaping the interaction between the oscillators and the radiation field in a manner which contradicts the assumptions of Newtonian-Maxwellian physics. The universal character of Planck's quantum hypothesis was subsequently confirmed in countless experiments.

However, the hypothetical "elementary oscillator," which Planck chose as the starting-point for his original analysis, was essentially equivalent to the one assumed in the classical case of "forced oscillations." In particular, the spatial extension of the oscillator itself is ignored in characterizing its interaction with the radiation field.

What happens if we drop this arbitrary assumption, and consider instead the case, where the amplitude of the oscillating body's motion is not small relative to the wavelength of the field? In that case, as it moves, the body experiences the field at different positions, as well as times. We thus have a case of "argumental oscillations" of a somewhat different sort than Doubochinski's pendulum; but which, in agreement with Doubochinski's principle, turns out also to have a discrete set of "quantized" amplitudes.[8] Those values can be calculated on the basis of general methods that he and his colleagues have developed.

The interesting point is, that Doubochinski's analysis does not depend in any explicit way on Planck's quantum of action, nor does it presuppose that the system be microscopic in scale. Laboratory experiments, carried out by Doubochinski and his collaborators on macroscopic systems simulating the idealized system under consideration, exhibit quantized amplitudes whose values are close to those predicted by his methods. This suggests that Doubochinski's discovery reflects a still more comprehensive principle than the Planck quantum of action, as presently understood—a general principle that would embrace the microscopic quantum of action, macroscopic quantization as demonstrated by Doubochinski's pendulum, and the characteristic quantization of astronomical systems, including not only the planetary orbits, but also such things as spiral-galactic arms and the rates of rotation of many astronomical objects. In fact, such a general principle is already implicit in the work of Johannes Kepler. It opens up a vast domain for further research.

It is important to emphasize the fundamental difference between Danil Doubochinski's approach and that of various physicists and mathematicians who, over the years, have attempted to derive the "quantization" of microscopic systems from classical mechanics, by introducing "nonlinear" terms in a more or less arbitrary way into the equations of motion. As we explained above, Doubochinski's amplitude quantization is an experimentally confirmed discovery of a real physical effect, which cannot be mathematically deduced from classical mechanics. Also, Doubochinski does not attempt to deduce Planck's blackbody radiation law or the laws of quantum mechanics from his principle; he merely calls attention to the striking coherence between quantum phenomena on the microscopic scale, and the behavior of argumental oscillations on the macroscopic scale.

Mathematical Methods

The essence of Doubochinski's general method for calculating the values of the quantized amplitudes is worth briefly mentioning here, because it provides a more synthetic viewpoint on the phenomena which we examined above, in somewhat painful detail, in the case of the pendulum.

We assume, in agreement with experiment, that the oscillating system, moving under the influence of a spatially inhomogeneous, high-frequency "field," will execute a quasi-periodic motion whose basic period is close to that of its natural, undisturbed motion, but whose amplitude and phase may vary in a certain fashion in adapting to the "field." Any periodic motion through a spatially inhomogeneous field has the effect of "modulating" the time-function of the external force, experienced by the oscillator, in such a way as to generate a large array of harmonic frequencies "spaced" at integral multiples of the base-frequency of the oscillator itself (Figure 10). If the external frequency is equal to an integral

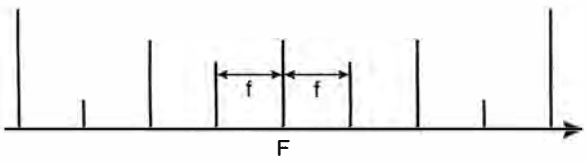


Figure 10
SPECTRUM OF SELF-GENERATED HARMONICS
Shown is the region of self-generated harmonics by the movement of the pendulum in the function that determines the action of the external force. The harmonics are frequencies of the approximate form of F – nf, where n is a whole number.

multiple of the undisturbed characteristic frequency of the oscillator itself, then that "natural" frequency will be among the harmonics. As a result, the pendulum can bring itself into resonance with the "signal," generated by its own space-time modulation of the external field, thereby drawing the power needed to maintain a stationary regime!

Those interested can find a detailed presentation of this method in the technical literature.[9] Here I only note the following: In the case of Doubochinski's modified Planck oscillator interacting with a monochromatic electromagnetic wave, the mathematical expression for the harmonics is connected with the trigonometric series for the result of the frequency-modulation of a sine wave by another sine wave of different frequency, which is well-known from radio technology. The coefficients of that series are given by Bessel's functions. In this manner, Doubochinski arrives at a formula for the quantized amplitudes of the oscillator in terms of extrema of the Bessel functions. In the case of Doubochinski's pendulum, one obtains very nearly the same values, as derived from our more elementary consideration of stationary regimes.

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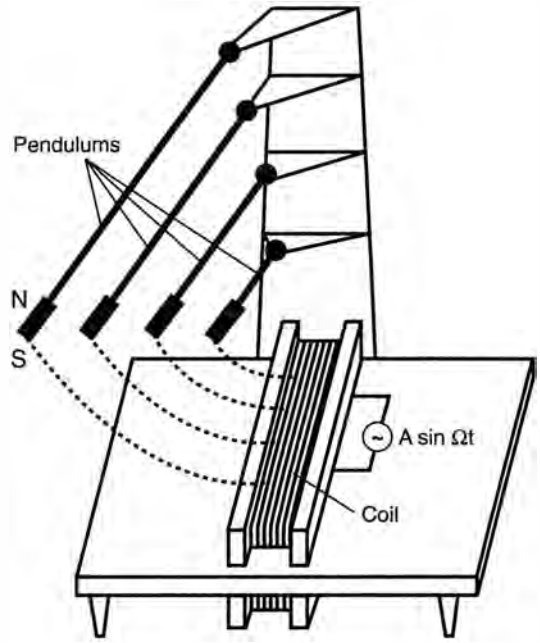


Figure 11
MULTIPLE ARGUMENTAL PENDULUMS
Multiple pendulums with different natural frequencies are driven by a single high-frequency magnetic field.

Notes

1. The photoelectric effect concerns the emission of electrons from a metal when irradiated by light. It is found that the energy of the individual emitted electrons is largely independent of the strength (amplitude) of the light, but increases with its frequency. For an atom or molecule irradiated by light, the energy levels to which the atom can be excited depend on the frequency of the light, but—except for extremely intense light—not on the light intensity. Generally speaking, the higher the frequency, the larger the range of discrete states that can be excited, up to the point of ionization.
2. By their very nature, standard computer algorithms for the solution of differential equations introduce artifacts which are present neither in the actual mathematical function described by the equation, nor in the real physical process. In the present case, where the value of the quantized amplitude is necessarily a discontinuous function of the initial conditions, the commonplace algorithms are doomed to fail. To develop useful computer methods for this sort of problem, it is necessary to take account of the essential features of the physical process, as demonstrated by actual experiments.
3. Doubochinski compares the mean radii of the planetary orbits with the calculated series of quantized amplitudes of a simple argumental oscillator (essentially Doubochinski's version of the Planck oscillator, described in the present article), scaled to the Earth orbit radius as "1." He finds that the values for the orbital radii agree quite closely with quantized amplitudes of the argumental oscillator (see Note 9). The latter series contains many amplitudes which do not correspond to observed planetary orbits; these amplitudes would correspond, if the analogy with a simple argumental oscillator holds up, to possible orbits which are not occupied in the present solar system.

   These additional orbits are not permitted, however, by Kepler's harmonic laws. The latter, it should be noted, identify key features of the solar system— particularly the unstable region of the asteroid belt—which are not accounted for by Doubochinski's simple model, and point to the action of a higher principle. This being said, Doubochinski's preliminary results are of great interest, pointing in the direction of an oscillatory theory of gravitation, for which many indications already exist.
4. Doubochinski points out that the functioning of the original Hertz oscillator, with which Heinrich Hertz first demonstrated the transmission of electromagnetic waves in 1888, depends on an effect of nonlinear "bundling" of electrons in the electrical discharge exciting the oscillator, which was not known or understood in Hertz's time.
5. In the 1940s and 1950s, Rocard observed the existence of stable regimes in a pendulum interacting with an oscillating magnetic field, and also wrote down a differential equation to describe the motion. However, he was not able to arrive at a satisfactory understanding of the phenomenon, nor did he apparently observe the quantization of amplitudes.
6. According to classical mechanics, the net change in velocity in traversing the zone of interaction, is equal to the time-integral of the force acting during the corresponding time, that is, the total area under the sine-wave curve enclosed between the moments of entry and exit from the zone.
7. Interestingly, Doubochinski's pendulum restores the "lost isochronicity" of the circular pendulum, by evolving toward a stable regime in which a constant amplitude is maintained.
8. It is worth noting, that in this case the dependence of the external force on the position of the oscillating body is a continuous function. Nevertheless, amplitude quantization occurs, just as in the pendulum, but with a different discrete series of amplitude values.
9. See, for example, the paper by D.B. and J.B. Doubochinski, "Amorçage argumentaire d'oscillations entretenues avec une série discrète d'amplitudes stables," *EDF Bulletin de la Direction des Etudes et Recherches,* Série C, Mathématiques, Informatique, No. 3, 1991, pp 11-20.

U.S. Auto Plants Never Just Produced Cars

by Marsha Freeman

There is a widespread misconception that the automobile industry in the United States is now in the throes of collapse because there is too much manufacturing capacity for the number of cars people can buy, and that there is nothing else that can be done with the auto industry's factories and machine-tool shops. Nothing could be further from the auto industry's own history.

Today, when dozens of manufacturing plants are being shuttered, and tens of thousands of skilled auto and machine-tool workers are losing their jobs, this manufacturing capacity, which is a national economic asset, must be converted to produce rail, advanced mass transit, energy, and other infrastructure systems, as Lyndon LaRouche has proposed. It has been done in the past. It must be done now.

Henry Ford, who created the system of mass production that made automobiles available and affordable for a large part of the nation's population, was born on a farm in Michigan, two years before the end of the Civil War. Ford hated labor-intensive farming, so the first experimental wheeled, motorized vehicle he developed in 1907, two years before his famous Model T car, was the tractor, or "automotive plow." Ford began mass producing tractors during World War I, and the company remained a major producer of tractors through the early 1960s.

In the 1930s, General Motors, established its Electro-Motive Division, producing diesel-powered locomotives and trains, contributing to the expansion of the nation's rail system. Later, the engines would be used in submarines and destroyers.

President Franklin Roosevelt's mobilization, to make the United States the "arsenal of democracy" during World War II, challenged the automobile industry to transform itself into a major supplier of high-technology war materiel.

The last automobiles rolled off the assembly lines in 1942, as the industry joined the full-scale war-production drive. Walter Reuther, president of the United Auto Workers union, and an expert tool-and-die maker, convinced the Roosevelt Administration that the auto industry should be retooled, pointing out that converting a plant to produce airplanes would take six months, while building a new plant would take 18.

Over the course of three years of war production, the auto industry built 27,000 complete planes, 455,522 airplane engines, 255,518 propellers, plus steel helmets, small-arms ammunition, and other items.

The challenge to the auto and machine-tool industries and their skilled workers, was that all of these had to be built to much higher tolerances and greater reliability than automobiles. Despite the skeptics, the industry accomplished it all, magnificently.

The Auto Industry in Space

At the start of the Space Age, Chrysler Corporation was the prime contractor for the Redstone rocket, a derivative of the World War II German V-2 rocket, which it built for NASA at its missile plant in Michigan. Chrysler also built the Jupiter Intermediate Range Ballistic Missile there, and during the Korean War, it built Army tanks at an unused manufacturing plant in Michoud, La., near New Orleans.

That plant was completely retooled by Chrysler in the early 1960s, 2,000 workers were hired and trained, and there they built the first stage of the Saturn V rocket that took Apollo astronauts to the Moon.

In the 1950s, Ford established its Aeronautics Division, developing tracking and radar both for the Air Force, and for NASA's Scout rocket and Mercury manned spacecraft. The Ford Instrument Company built the guidance systems for the Jupiter and Redstone rockets. In the 1950s, Ford Aerospace and Communications built commercial communications satellites.

General Motors bought Hughes Aircraft in 1985, and combined it with Delco to create GM Hughes Electronics, which worked on aircraft and spacecraft. In 1992, GM purchased General Dynamics Missile Systems, producing communications satellites.

The space program would not have been possible without the machine tool, manufacturing, and research and development capabilities of the Midwest, centered around the mass-production auto industry. In addition to Chrysler and Ford, McDonnell Douglas in St. Louis built the Mercury spacecraft; a B.F. Goodrich engineer in Akron, Ohio designed the first high-altitude pressure suit; and Cincinnati Testing and Research Lab built the heat shield for the Mercury space capsule.

Auto-parts supplier TRW produces components for the aerospace industry. Automobile-tire producer Goodrich Corp. in Troy, Ohio, made the tires, brake assemblies, wheels, and landing gear for the Space Shuttle. In its huge Canton, Ohio, research facility, the Timken Company designed the precision ball bearings that are on the *Spirit* and *Opportunity* rovers that are now exploring Mars.

Tomorrow's Transport: Maglev

The most natural application of the auto industry's capacity is to other vehicles with an internal combustion engine and, usually, wheels. These include aircraft, rockets, spacecraft engines, trains, trucks, tractors, construction equipment, and so on.

In addition to the rebuilding and expansion of America's decrepit freight-rail and passenger systems, a new technology on the horizon will be even a greater challenge.

Magnetically levitated transport, or electromagnetic flight, is the future of

Howard R. Hollem/National Archives

Workers at Ford Motor Co.'s Willow Run plant, which was converted during World War II to produce B-24E bombers.

transportation. So far, commercial maglev systems are in operation only in Shanghai, China, and in Nagoya, Japan. Maglev vehicles replace wheel-on-rail trains, using magnetic systems for levitation and propulsion. Without friction, maglev vehicles can safely and quietly attain speeds of 300 miles per hour, or more.

The maglev vehicle itself most resembles an airplane, not a train, in everything from materials to its aerodynamic design. It is likely that, as in the German Transrapid design, the passenger vehicles would be manufactured in the currently under-utilized aircraft/machine-tool industry.

But the other major maglev components include magnetic and electrical/electronic components, which would be well suited for production by auto-parts producers, when one considers the array of components in a car today that are electronic.

Tomorrow's Energy: Advanced Nuclear

The U.S. nuclear industry has not built a new power plant in this country for 30 years. Much of the U.S. manufacturing capability has disappeared, and new reactors today would have to depend upon imports for large components, such as reactor-pressure vessels. Without the construction of hundreds of new nuclear plants in the United States over the next decade or so, there will be no possibility for rebuilding our industrial expansion. The increasingly idle auto industry can be key.

We must start building nuclear power plants in the United States immediately, using standardized advanced light-water reactors, which are passively safe, more economical and efficient, and are faster to build and require less maintenance than the 1970s generation now in use. Although none has been built in the United States, the Nuclear Regulatory Commission has approved and certified the Westinghouse AP1000 design, and will soon certify the General Electric ESBWR. The new generation of GE reactors has been built in less than 48 months in Japan.

These advanced light-water reactors should be ordered immediately by U.S. utilities. The first place to start building them is at "brownfield" sites, where there is already an operating reactor, and where the site had been prepared for additional units in the 1970s, which were later abandoned. At the same time, dozens more sites should be prepared for hundreds of new plants.

To supply them, we must set up, virtually from scratch, assembly-line manufacturing plants. Pumps, piping, electronic controls, and other nuclear plant components can be produced in upgraded auto-parts factories.

During its 30-year nuclear hiatus, the United States has fallen decades behind in development of the more advanced, so-called fourth-generation reactor designs, such as the high-temperature gas-cooled pebble-bed reactors. Today, only South Africa and China are developing prototype reactors using this critical technology, while the American company General Atomics is building its prototype fourth-generation GT-MHR in Russia.

The in-depth research and development capabilities of the auto industry, along with a national crash development program, are needed not only to "save" the auto industry, but also to recreate the U.S. economy, and finally deploy technologies like maglev and advanced nuclear power.

The Beauty of the Nuclear Fuel Cycle

by Marjorie Mazel Hecht

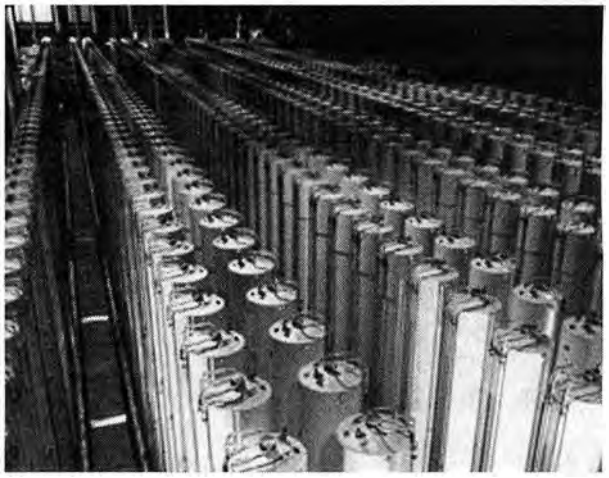
It would take 2 million grams of oil or 3 million grams of coal to equal the power contained in 1 gram of uranium fuel.[1] Unlike oil and coal, nuclear fuel is recyclable and, in a breeder reactor, it can actually produce more fuel than is used up! For these reasons, nuclear energy is by far the best means now available to power a modern industrial economy.

Nuclear power is truly a gift to humanity, and only the propaganda of Malthusian extremists, dedicated to stopping human progress and reducing the world's population, has created public fear and skepticism.

The best way to overcome irrational fear is through knowledge. To this end, reviewed here is the process by which natural uranium ore is turned into fuel for a nuclear reactor, how it is used, and how it can be recycled, such that the reader will come to understand that there is really no such thing as nuclear "waste."

The Nuclear Fuel Cycle

To understand the "renewability" of nuclear fission fuel, we have to look at the complete fuel cycle. At the beginning of the nuclear age, it was assumed that nations would complete the fuel cycle—including the reprocessing of spent nuclear fuel from reactors, to get as near to 100 percent use of the uranium fuel as possible. Here we very briefly review the seven steps of this cycle. Keep in mind that the brevity of description leaves out details of the complex chemical processes, which were initiated during the Manhattan Project and are still being improved on.



DOE

An overhead view of rows of centrifuge units at a U.S. enrichment plant in Piketon, Ohio.

1 First, natural uranium is mined. There are enough sources of uranium worldwide for today's immediate needs, but once we begin an ambitious nuclear development program (to build 6,000 nuclear reactors in order to provide enough electricity to bring the entire world population up to a decent living standard), we would have to accelerate the development of fast breeder nuclear reactors, which produce more fuel than they consume in operation.

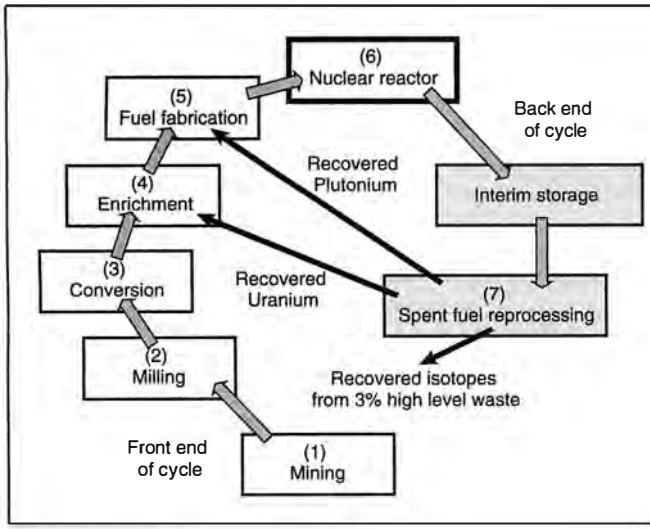
2 Next, the uranium is processed and milled into uranium oxide U_3O_8, called yellowcake, which is the raw material for fission fuel. Yellowcake became infamous in the political fabrication that Saddam Hussein's Iraq was trying to import yellowcake from Niger, in order to use it for bomb-making.

It is basically natural uranium ore, which is crushed and processed by leaching (with acid or carbonate) to dissolve the uranium, which can then be extracted and concentrated to 75 percent uranium, in combination with ammonium or sodium-magnesium.

3 The concentrated uranium is then converted into uranium hexafluoride (UF_6), which is heated into a gas form suitable for enrichment.

Uranium Enrichment

4 Natural uranium has one primary isotope, U-238, which is not fissionable, and a much smaller amount of U-235, which fissions. Because most uranium (99.276 percent) is U-238, the uranium fuel must go through a process of enrichment, to increase the ratio of fissionable U-235 to the non-fissionable U-238 from about 0.7 percent to 3 to 4 percent.



COMPLETING THE NUCLEAR FUEL CYCLE

The full nuclear fuel cycle shows that nuclear is a renewable energy source, because the spent fuel can be reprocessed to recover unburned uranium and plutonium that can be fabricated into new reactor fuel. At present, the U.S. nuclear cycle is "once through," going from spent fuel to interim storage and then longer-term storage.

Frank Hoffman/DOE

The huge Gaseous Diffusion Plant in Oak Ridge, Tenn., the first such facility in the world. The U-shaped building, constructed during the Manhattan Project, began operating in 1945. Later, the facility was expanded to produce enriched uranium for plants around the world.

(Weapons uranium is enriched to about 93 percent U-235.)

The technology of enrichment was developed during the World War II Manhattan Project, when the object was to create highly enriched uranium (HEU) to be used in the atomic bomb. Civilian power reactors use mostly low-enriched uranium (LEU). (Canada has developed a type of reactor, the CANDU, which uses unenriched, natural uranium in combination with a heavy water moderator to produce fission.)

The gaseous diffusion method of enrichment, which is still used by the United States, was developed under the Manhattan Project. Uranium hexafluoride gas is pumped through a vast series of porous membranes—thousands of miles of them. The molecules of the lighter isotope (U-235) pass through the membrane walls slightly faster than do the heavier isotope (U-238). When extracted, the gas has an increased content of U-235, which is fed into the next membrane-sieve, and the process is repeated until the desired enrichment is reached. Because the molecular speeds of the two uranium isotopes differ by only about 0.4 percent, each diffusion operation must be repeated 1,200 times.

The Manhattan Project devised this method of gaseous diffusion with incredible speed and secrecy. It was not finished in time to produce all the uranium for the uranium bomb dropped on Japan, but it produced most of the enriched uranium for the civilian and military programs in subsequent years. Although a successful method, it required a tremendous amount of energy and a huge physical structure to house the "cascades" of separate membranes. Four power plants were built in Oak Ridge, Tenn., to power the process, producing as much electric power as the consumption of the entire Soviet Union in 1939! Almost all the power consumed in the diffusion process is used to circulate and compress the uranium gas.

Technological pessimists take note: At the time the gaseous diffusion plant was being built, scientists had not yet figured out how to make a membrane to be used in the process—but they did it in time to make it work!

The centrifuge system, used in Europe and Japan, is 10 times as energy efficient. The strong centrifugal field of a rotating cylinder sends the heavier isotope in uranium hexafluoride to the outside of the cylinder, where it can be drawn off, while the U-235 diffuses to the inside of the cylinder. Because of the limitations of size of the centrifuge, many *thousands* of identical centrifuges, connected in a series called a cascade, are necessary to produce the required amounts of enriched uranium.

A centrifuge plant requires only about 4 percent of the power needed for a gaseous diffusion plant, and less water is needed for cooling.

Other methods of enrichment are possible—electromagnetic separation, laser isotope separation, and biological methods.

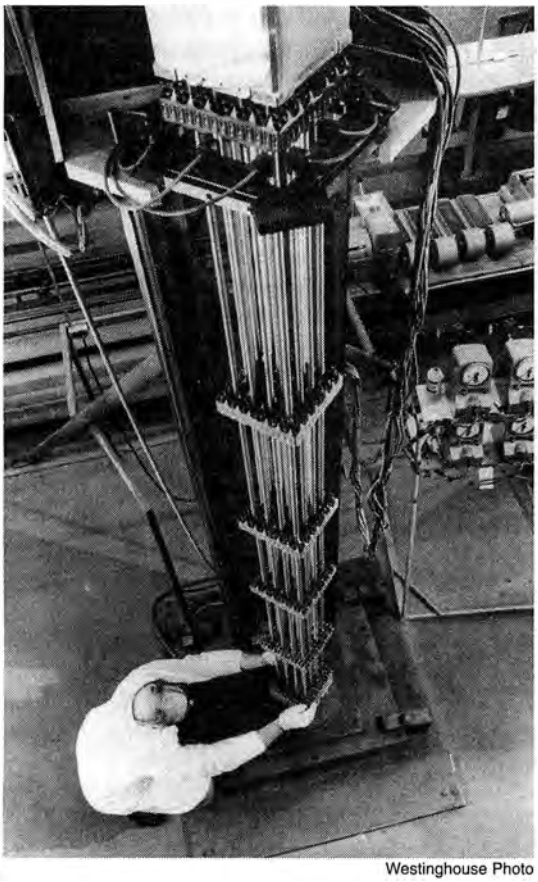
Fabrication into Fuel Rods

5 Once the enriched uranium is separated from the depleted uranium, it is converted from UF_6 into uranium dioxide and fabricated into uniform pellets. The pellets are loaded into long tubes made out of a zirconium alloy, which captures very few neutrons. This cladding prevents the release of fission products and also transfers the heat produced by the nuclear fission process in the fuel. The fuel is then transported to the reactor site.

Different types of reactors require different designs of fuel rods and fuel bundles. In a light water reactor, the fuel rods are inserted into the reactor to produce fission, which creates steam which turns a turbine that creates electricity.

U.S. AEC

A cylinder of uranium hexafluoride enriched in U-235 is readied for shipment to a conversion facility, where it will be converted to uranium dioxide for use in fuel rods. The cylinder weighs 2.5 tons.



Westinghouse Photo

A partially completed nuclear fuel assembly. The long tubes guide the control rods in the reactor, which regulate its operation. The grids that hold the guide sheaths also align the fuel rods containing uranium pellets. When the fuel rods are inserted through the grids, parallel to the guide sheaths, the fuel assembly will be completed.

The fuel for the next-generation high-temperature gas-cooled reactors is different: The enriched uranium is formed into tiny "pebbles" which are coated with graphite and special ceramics that serve as individual "containment buildings" for the fuel pebbles.

6 Fuel rods are used for about four and a half years before replacement, and usually a reactor replaces about a third of its fuel at one time. The fuel is considered spent when the concentration of fissile uranium-235 becomes less than 1 percent. When removed from the reactor, the spent fuel is put into cooling pools, which shield it as its short-lived nuclides decay. Within a year, the total radioactivity level is only about 12 percent of what it was when the fuel rod came out of the reactor.

At present, the United States does not reprocess spent fuel, and so the spent fuel rods sit in cooling pools at the reactor. After the spent fuel has cooled, it is stored in dry casks, waiting—for "burial" or reprocessing.

But the spent fuel is not "waste"! It contains between 90 and 96 percent of usable uranium, that can be separated out and recycled into new fuel, and it also contains a smaller amount—about 1 percent—of plutonium, a fuel for breeder reactors.

Reprocessing

7 Now for the remarkable *renewability* of nuclear fuel. The spent fuel from a single 1,000-megawatt nuclear plant, operated over 40 years, is equal to the energy in 130 million barrels of oil, or 37 million tons of coal. Why bury it? Extract it and process it into new fuel. Short-sighted policy makers (discussed below) decided in the 1970s, for no good reasons, that it was preferable to prevent the full use of this potential by burying the spent fuel in a once-through cycle.

The reprocessing method that was successfully used in the United States at the Savannah River facility in South Carolina for military purposes is just as efficient for civilian spent fuel. Spent fuel rods are processed to remove the highly radioactive fission products (3%), and separate out (partition) the fissionable U-235 (96%) and plutonium (1%).

This plutonium could be directly used as fuel for breeder reactors, which was the intention of the completed fuel cycle. It can also be used to make mixed-oxide fuel, or MOX, which some of today's reactors are being converted to burn as fuel. (Thirty-five reactors in Europe now use MOX fuel.)

The reprocessing facilities at Savannah River were called "canyons" because they were tall, narrow buildings. The spent nuclear fuel was handled remotely by technicians who were behind protective walls. This was large-scale industrial processing, which was entirely successful, safe, and safeguarded.

Once the uranium was separated out, it was sent to another building at Savannah River to be fabricated for weapons use. The remaining amount of highly radioactive fission products—a tiny fraction of the spent fuel—was set aside for vitrification and storage. Today, the technologies exist, or could be developed, to extract valuable medical and other isotopes from this 4 percent of high-level waste. Virtually all of the spent fuel could be made usable.

U.S. civilian spent fuel could be reprocessed in a similar fashion using the Savannah River model—or by new technologies still to be developed.[2] Right now, Britain, France, Russia, and India reprocess civilian spent fuel, using the Purex method (which stands for Plutonium Uranium Extraction), and Japan has a commercial reprocessing plant now in a testing start-up phase. Other nuclear nations send their spent fuel to Britain or France for reprocessing, or they store it. China reprocesses military spent fuel.

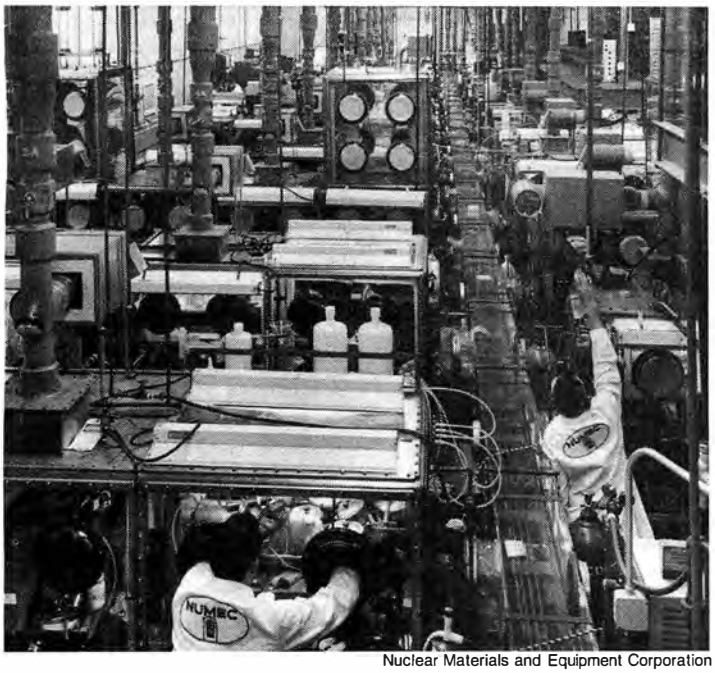
Who Opposes Reprocessing?

Reprocessing makes the antipopulation faction very nervous, because it implies that nuclear power will continue to develop as a source of electricity, and with a cheap and clean source of power, there are no limits to growth. Malthusians and other alarmists rant about the "dangers of proliferation," but if you poke them, what they are really concerned about is the potential for nuclear energy to expand, and population and industrial development to grow.

The overt arguments against reprocessing are mostly scare tactics: Permitting U.S. reprocessing will make it easier, they say, for "bad guys" to build bombs—or dirty bombs. This is the gist of the objection, although it may be posed at length in more academic (and tedious) language.

But this argument is one based on fear—fear that an advanced technology can never be managed properly, *and* fear that we will never have a world where there aren't "bad guys" who want to bomb us. It is the opposite of the Atoms for Peace philosophy.

In fact, if one is truly worried about diversion of plutonium, why not burn it



Nuclear Materials and Equipment Corporation

In this 1964 photo, laboratory technicians work in glove-boxes to remotely fabricate plutonium fuel elements.

E.I. DuPont DeNemours & Co

A 1972 photo of high-level waste storage tanks in construction at DOE's Savannah River Plant in South Carolina. The tanks are built of carbon steel, surrounded by concrete encasements 2 to 3 feet thick, set about 40 feet in the ground and then covered with dirt. Shown are the steel tanks before concrete encasement. Each tank has a capacity of from 750,000 to 1,300,000 gallons.

to produce electricity, instead of letting it accumulate in storage? And as Savannah River manager William P. Bebbington, a veteran of the Manhattan Project wrote in a landmark 1976 article on reprocessing, "Perhaps our best hope is that someday plutonium will be more valuable for power-reactor fuel than for weapons, and that the nations will then beat their bombs into fuel rods."[3]

A second objection is that reprocessing is not "economical"; it is cheaper to have a "once through cycle" and discard the spent fuel. But the cost/benefit basis on which such economics are calculated is a sham. What is the cost of *not* reprocessing—in terms of lives lost and society not advancing? And what about the cost of the storage of spent fuel—not to mention the still unused U.S. storage facility at Yucca Mountain, Nevada, which has become a costly political and emotional football.

The "proliferation" argument was key in 1976 in stopping U.S. reprocessing. Fear was fed by the idea that reprocessing would make more plutonium available, which could be diverted by "rogue" nations or groups to make clandestine nuclear weapons. President Ford, the incumbent, carried out a secret study, and issued a nuclear policy statement on Oct. 28, 1976, just five days before the election, which advocated an end to reprocessing.

Jimmy Carter, who won that election, then carried out the policy to stop U.S. reprocessing; and the next President, Ronald Reagan, sealed the lid on the fuel-cycle coffin with the idea of "privatizing" both reprocessing and breeder reactors.

The full story of how reprocessing was stopped still has to be told. But the ending of the story is clear: The United States shot itself in the foot—twice: (1) The United States stopped an important technology, which this country had pioneered, and (2) the U.S. anti-reprocessing policy did *absolutely nothing* in the rest of the world to stop other countries from developing the full nuclear fuel cycle, or desiring to.[4]

Interestingly, the Ford Administration's policy in 1976, which advocated killing U.S. reprocessing for the same fallacious reasons that President Carter later elaborated, was written under the direction of Ford's chief of staff—Dick Cheney. And one of the key reports supporting Carter's ban on reprocessing was written by the mentor of the leading neo-cons in the Bush Administration, Albert Wohlstetter, then a consultant to the Department of Defense.

Once the political decision is taken to begin an ambitious nuclear construction program, reprocessing—both Purex and new technologies—will follow.

Notes

1. The energy density of nuclear can be seen by comparing fission fuel to other sources. In terms of volume of fuel necessary to do the same amount of work, a tiny pellet (1.86 grams) of uranium fuel equals 1,260 gallons of oil, or 6.15 tons of coal, or 23.5 tons of dry wood. This means that nuclear is 2.2 million times more energy dense than oil, and 3 million times more energy dense than coal. Thermonuclear fusion will be even orders of magnitude more energy dense. These calculations were based on the work of Dr. Robert J. Moon in 1985.
2. The U.S. Congress in the 2005 Energy Act included $50 million for research on new reprocessing methods.
3. "The Reprocessing of Nuclear Fuels" by William P. Bebbington, *Scientific American*, December 1976, pp. 30-41.
4. Commenting on President Carter's 1977 policy to shut down reprocessing and the Clinch River Breeder Reactor, Bernard Goldschmidt, a pre-eminent French nuclear scientist, who had studied with Marie Curie, wrote: "By this extraordinary and unique act of self-mutilation, an already declining American industry was to become paralyzed in two key sectors of future development, fuel reprocessing and breeder reactors, precisely the sectors in which the United States was already between 5 and 10 years behind the Soviet Union and Western Europe, in particular, France. . . ."

For Further Reading

Scott W. Heaberlin, *A Case for Nuclear-Generated Electricity . . . or why I think nuclear power is cool and why it is important that you think so too* (Columbus, Oh.: Battelle Press, 2004).

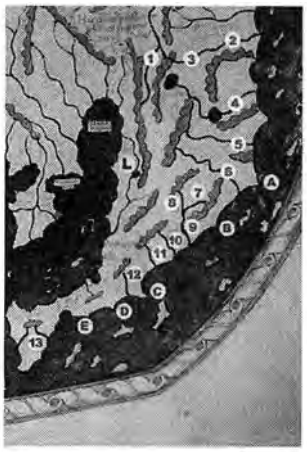
Alan Waltar, *Radiation and Modern Life* (Amherst, N.Y.: Prometheus Books, 2004).

See also: http://www.world-nuclear.org/education/education.htm on the fuel cycle.

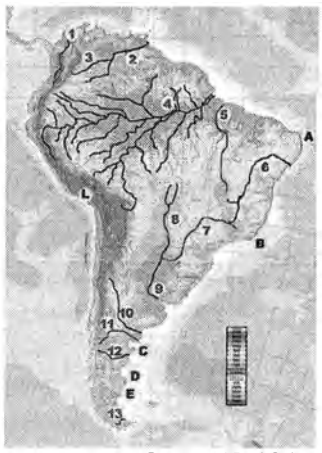
A Pre-Columbus View of the Americas

by Rick Sanders

La Cola del Dragon (The Tail of the Dragon), in Spanish
by Paul Gallez
Argentina: Bahía Blanca, 1990
Hardcover, 184 pp., $ 80.00
(Published in German as *Das Geheimnis des Drachenschwanzes: Die Kenntnis Amerikas vor Kolumbus*, (Berlin: Dietrich Reimer Verlag, 1980.)



Key to Rivers and Other Features
1. Magdalena
2. Orinoco
3. Meta
4. Amazonas
5. Tocantins
6. San Francisco
7. Paraná
8. Paraguay
9. Rio de la Plata
10. Colorado
11. Negro
12. Chubut
13. Rio Grande
A. Cabo San Roque
B. Cabo Frio
C. Peninsula Valdés
D. Cabo Tres Puntas
E. Cabo San Fco. de Paula
F. Lago Titicaca



Courtesy of Paul Gallez

At left is a section of a 1489 map, showing South America's river system; a modern map is on the right. The rivers and other locations are numbered on both maps, as indicated by the key.

The enigma with which Dr. Gallez presents us is a map, four versions of which are in existence today, drawn by German cartographer Heinrich Hammer, who belonged to the school of the great Nicholas of Cusa. All four copies of the map were made in 1489, and they show South America as part of Asia—as the tail on the Chinese dragon.

This is both interesting and devastating, because of the indisputable fact that the map more accurately depicts the entire river system of South America than any other for another 400 years! So, it gives the lie to the establishment's isolationist theories that deny any European or Asian contact with the Americas before the Vikings and Columbus.

The author, Dr. Paul Gallez, was born in Belgium in 1920, and in his long career has been a physical economist; historian; civil engineer; professor of French, English, and German; and prehistorian. He has written more than 230 articles, and translated and authored numerous books in all of his fields of expertise. This book has abundant illustrations and maps, and a foreword by the distinguished Dr. Hanno Beck, director of the research department of the Humboldt Society in Mannheim, Germany.

Unfortunately, this delightful book has had limited publication and circulation. It is not yet available in the English language, but only in Spanish and German. Indicative of the obfuscation of human history that still grips academia, is the lamentable fact that the Spanish edition of this book was published in only 300 copies.

Unanswered Questions

There are many unanswered questions, some dealt with in this very densely packed book, which I will not pretend to discuss here in full, but rather try to pique your interest, and drum up support for an English publication. One thing is certain: It will be a very bitter pill to swallow for the isolationists who claim that the "Indians" crossed the Bering Strait when it was dry, sometime around 12,000 B.C., and who deny all Asian or European contact with the "new" world until the Vikings or Columbus.

Paul Gallez stands out for his intellectual integrity, by joining those relative few who point out that the "geographer" Ptolemy, is a plagiarist and a slanderer. Gallez notes that Ptolemy did not bring anything new to geography; he took everything from Marino of Tyre, whom he ridiculed for saying that more than half of the spherical world was inhabited. Thereupon, Ptolemy squeezed the world into 180 degrees of longitude and 90 degrees of latitude, and kept it imprisoned there during the Dark and the Middle Ages.

Origins of the Map

Gallez lays out three hypotheses for the origin of the map:

(1) The Chinese hypothesis: It is said in the Chinese Annals, that in the year 219 B.C., the emperor Qin Shihuangchi sent out "an expedition of young men and women to a wonderful country lying far off to the east, across the ocean, called Fu-Sang. The young people settled there and were happy."

(2) The Egyptian hypothesis: From about 2550 B.C., fleets of Egyptian ships travelled to "Punt," in ships about as big as the *Santa Maria,* in voyages that would last three years. They did this off and on for 1,400 years, bringing back gold and antimony, a metal totally unknown in Egypt and the neighboring countries.

Gallez thinks that Punt, whose location is still in dispute, was the Puno region on the shores of Lake Titicaca in Peru, where 70 percent of the gold of Peru, as well as antimony, is mined today. The reed boats on Lake Titicaca, look so much like those of ancient Egypt, that Thor Heyerdahl went to Puno to recruit the men who built his papyrus boat, *Ra II,* on the shores of the Nile. Heyerdahl successfully sailed *Ra II* from Morocco to the West Indies, following in the footsteps of Columbus—and who knows how many others before or after him.

(3) The Phoenician hypothesis. The maritime fame of the Phoenicians goes back to 2400 B.C. King Solomon asked Hiram of Tyre (in Phoenicia) to get him the cedar for the Temple in Jerusalem, and to send carpenters for building a fleet on the Red Sea, to sail to "Ofir," whose location, says Gallez, could correspond to the Egyptian "Punt."

What Is Not Known

When dealing with pre-history, what you do not know is often more important than what you do know; and when exploring this domain, you cannot be afraid of paradoxes or uncertainty. Gallez reminds us that "the experts seem determined to defend a pre-established theory rather than to seek a scientific truth, for fear that this might endanger the ideas they have been expounding for years."

APOLLO'S LEGACY

A Gift from the Past to the Future

by Marsha Freeman

MOVIE REVIEW

"Magnificent Desolation: Walking on the Moon 3D"
IMAX Corporation, 2005, 40 min.

For those of us who remember watching the Apollo astronauts take their first tentative steps on the surface of the Moon 36 years ago, the memory may be vivid, but all we could really see were gray and ghostly images; all we could really hear were garbled sounds. This new IMAX film recreates the Apollo program, and takes us to the Moon.

But "Magnificent Desolation" was not produced so old-timers could reminisce about the halcyon days of the Apollo program. The film begins and ends with children—the astronauts of tomorrow who will walk on the Moon—and shows them this spectacular adventure through the eyes of the astronauts who experienced it.

Because the film is in three dimensions, requiring that the audience wear polarized glasses, there is no way to describe the visual effects in words. What narrator/co-writer/producer Tom Hanks has done is to bring alive what the Moon was like for the astronauts then, and what it will develop into, in the future.

The film begins with interviews of young children who are visiting the California Science Center. They try to answer questions about who the astronauts were who went to the Moon, what they did there, and so forth. Although the responses are charming and entertaining, they are a sad reminder of how few in their parents' generation have made the accomplishment of landing on the Moon real for tomorrow's potential astronauts.

The purpose of the film is to bring to this young generation the inspiration that the Apollo program was in the 1960s to many of their now-graying parents and grandparents.

Tom Hanks was 13 years old when Neil Armstrong and Buzz Aldrin landed on the Moon. That this event had a lasting impact on him is evidenced by his work—his leading-role portrayal of astronaut Jim Lovell in the film "Apollo 13," and his producing, writing, and appearance in the six-part TV miniseries, "From the Earth to the Moon."

Hanks describes the landing on the Moon as "an evolutionary step" in man's history. "That meant that everything prior to that was going to be measured by this watermark," he explains. "Here was the proof that anything can happen."

You Are There

The central aspect of the film is what the Moon looked like as the astronauts saw it, how they landed there, and what activities they carried out. The movie, four years in the making, is based on film footage taken by the astronauts, some of which NASA had never released before, thousands of still photographs, and the counsel of Dave Scott, Apollo 15 astronaut.

The original Apollo footage that is included is recognizable by its poor quality, by today's standards, and by the fact that it is largely in black and white. What the film's creators have done, with attention to the minutest detail, is to use the original material to recreate the space suits, Apollo hardware, and vistas of the Moon not only in color and magnificent clarity, but in three dimensions.

You are there.

You are standing near an actor portraying Neil Armstrong, virtually looking over his shoulder, as he takes his "giant leap for mankind." You are watching from a few yards away as the astronauts traverse the Moon in their rover, or as they collect rocks. You are standing next to them inside the cramped Lunar Excursion Module as they prepare to go outside to explore.

The scenes on the Moon are breathtaking. They are technically accurate down to the smallest detail, and after awhile, you do not make a distinction in your mind as to what was filmed by the Apollo astronauts, and what has been so accurately created by the film makers. The broad vistas are what you would see, could an airplane take you on a swing around the Moon.

The Woman on the Moon

During the central section of the film, an incident involving Apollo 16 astronaut Charlie Duke is reenacted. Duke had carried with him to the Moon a photograph of his family. Granted a "personal moment" by NASA, Duke removed the photograph from a pocket of his space suit, placed it on the ground, and photographed the picture of his family, on the surface of the Moon.

At the start of this film, one of the children interviewed at the California Science Center is a little girl named Veronica Lugo, who has drawn a picture of herself on the Moon. At the end of the film, now a grown woman, and the commander of a lunar colony that includes living quarters, telescopes, and helium-3 storage facilities, tomorrow's Veronica Lugo is portrayed taking out of a pocket in her spacesuit, the drawing she had made as a child of herself on the Moon, and placing it on the lunar surface.

The scene is reminiscent of a film made in 1984 for Lyndon LaRouche's Presidential campaign, called "The Woman on Mars." The opening scene in that production is the announcement of the activation of the first colony on Mars, also made by a woman, also of Hispanic origin.

The last image on the screen of "Magnificent Desolation," is a quote, indicative of the universality of man's misson to explore, but not from an Apollo astronaut or President Kennedy: "Man must rise above the Earth—to the top of the atmosphere and beyond—for only thus will he fully understand the world in which he lives.—Socrates."

"Magnificant Desolation" opened in many IMAX theaters internationally on Sept. 23, and opens later at other locations. Check www.imax.com/magnificentdesolation for details, and go to see it!

Despite Much Talk, Bird Flu Is Spreading

by Christine Craig

Turkey, which saw its first infections of highly pathogenic H5N1 avian influenza in poultry flocks last October, has just confirmed human infections: Three children died and at least two others lie ill in the poor eastern province of Igdir, bordering Iran. Turkey is a poor country, and the disease has hit hardest in its poorer areas, where livestock practices are similar to those in Southeast Asia—backyard flocks, often slaughtered on site, with no biosecurity.

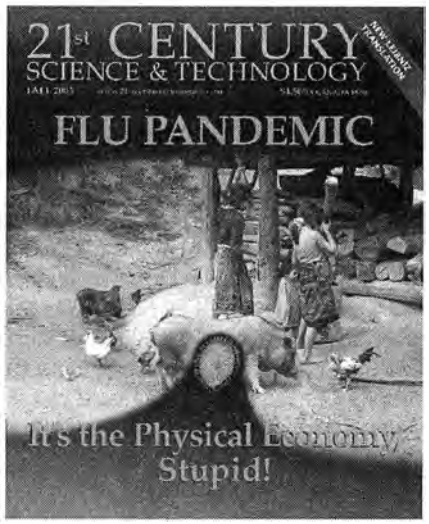
The flare-up in Turkey, a nation straddling Europe, Asia, and Africa, is ominous. If the outbreak becomes widespread there, then Iran, North Africa, and Southeastern Europe—all poor, underdeveloped regions—are also threatened. With each new infection the danger increases of a mutation or reassortment of the deadly influenza virus into a form that is easily transmissible from human to human.

Migration of infected wild waterfowl from east Asia during October 2005 brought the bird flu to many other nations as well, including Mongolia, Russia, Kazakhstan, Romania, and Croatia. The disease flared up again in several areas of China, devastating poultry flocks and infecting several human beings. It became well-entrenched among the far-flung islands of Indonesia, and re-emerged in Thailand after a lull. In all, 16 nations have seen outbreaks since 2004.

The total toll the virus has exacted on human beings in 2004 and 2005, is approximately 146, with 76 fatalities; the number of domestic poultry killed by the virus or through culling, has topped 140 million.

Little Progress

Truthfully, despite the warnings of the experts, endless national and international meetings, high words, and the allocation of billions in funding, little progress has been made to stamp out the pestilence which has plagued fowl and threatened man. This should come as no surprise, once the nature of pestilence is understood. Epidemics are societal diseases. The spreading pestilence among poultry is reality smacking us, indicting us for our neglect of the proper economic, scientific, and cultural development absolutely necessary to sustain present population densities in the poorer areas of the world.



"Flu Pandemic: It's the Physical Economy, Stupid!" is the cover story of the Fall issue of 21st Century.

As populations have increased in Southeast Asia—ground zero for the bird flu poultry pandemic—and as people have gained the means to increase their protein consumption, poultry density has skyrocketed. However, the veterinary biosecurity and public health practices that must accompany high-density poultry operations are frequently lax or inadequate. One international virologist believes that the outbreak originated in lax practices by a major Southeast Asian producer, which permitted the transport of infected animals and contaminated equipment and workers across borders.

And husbandry practices have not changed for most rural landholders. Backyard flocks mix intimately with pigs and people, often sleeping in close proximity. Fighting cocks are highly prized vectors of infection, transported long distances to mix with new flocks and people. The crowded "wet" markets, cherished in Southeast Asia, are perfect environments to exchange diseases.

What is needed is infrastructure building: modern agricultural and manufacturing practices supported by transportation, water, energy, health, and education infrastructure. Without these, we are endlessly battling the unwelcome guest—pestilence.

The Only Security—Development

Developed nations have the veterinary tools to fight the avian flu. Mass vaccination of poultry, along with culling, can beat down the disease. If done properly, as was done in Japan, South Korea, and Hong Kong during previous outbreaks, it can eliminate the disease, but only if the society has the will and means to change its practices.

In the absence of such changes, the disease will fester and spread among poor nations, as it is poised to do in Turkey. And eventually, if not with H5N1, then with another such pestilence, the human pandemic will occur.

Developed nations are now working assiduously to protect themselves, with money pouring into vaccine and antiviral technology and production. If the pandemic is delayed in its coming, we will, probably within five years, have the means for a vaccine potent against all strains of flu. The developed nations will have a variety of antivirals at our disposal. We will be "secure" against the dreaded influenza, even if the disease continues to devastate poultry in poor countries.

Will we then have the political will to take our resources to the poorest countries to make them secure, or, as with AIDS, tuberculosis, and malaria, will we leave them to their fate? Tuberculosis should have taught us the folly of that approach. Diseases festering in the wings tend to creep back, given the least opportunity. New ones move in.

Developed nations can never be secure while so many nations are neglected. What Lyndon LaRouche has emphasized for over 30 years in warning of a pandemic threat, has never been more crucial than today. In the end, the only real security is through development.

Korea's Yongwang nuclear complex, with its lineup of six reactors. Korea's electricity is 56 percent nuclear.

Courtesy of Korea Hydro & Nuclear Power Co., Ltd.

Nuclear Energy: The Way to Restart Progress

Nuclear energy is the only road to recovery for the United States and for the rest of the world. No other energy source can power a modern industrial nation, and lift the world's population out of poverty.

The nuclear fuel cycle is unique. As reviewed in our Nuclear Report, just 1 gram of uranium fuel, fabricated from the yellowcake (uranium oxide) shown here, equals the power output of 2 million grams of oil. Not only is fission more energy dense, but the fuel is recyclable and, in a breeder reactor, can actually produce *more* fuel than is used up.

Right now, the United States has a "once through" cycle, and spent nuclear fuel is stored for later burial. But what is erroneously called nuclear "waste" is actually a valuable resource whose unused uranium and plutonium can be recycled into new reactor fuel. The 3 percent of the spent fuel that cannot be recycled can be "mined" to retrieve valuable isotopes for medical and industrial use.

America in the 1960s was ready to go with the complete fuel cycle. There was a "can-do" approach to inventing the necessary technologies. Today's generation can do it too.

Areva/Olivier Martel

Yellowcake, the raw material for nuclear fuel, at the Cominak uranium ore processing plant in Niger.

Areva/Philippe Lesage

Yellowcake on a belt filter at the ore processing plant operated by the Société des Mines de Jouac in France.

In This Issue

Fusion

AMPLITUDE QUANTIZATION IN DOUBOCHINSKI'S PENDULUM

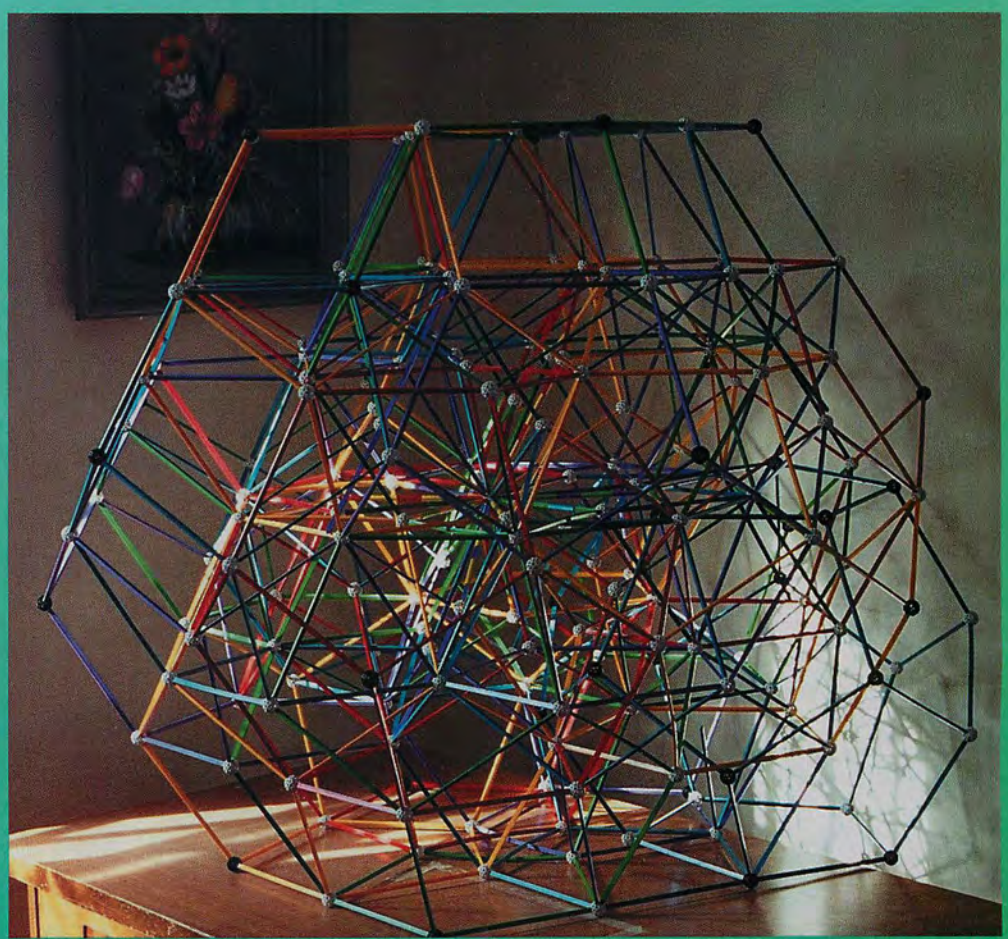
While students at Moscow University in 1968, Danil Doubochinski and his brother Yakov discovered the phenomenon of quantization of amplitudes in macroscopic oscillating systems. Jonathan Tennenbaum reports on the subsequent development of that new physical principle, and its revolutionary implications for physics.

Danil Doubochinski with one of his pendulums which demonstrates the principle of argumental oscillations.

A KEPLERIAN SOLUTION TO THE QUASICRYSTAL PARADOX

In Research Communications, Laurence Hecht presents a construction which permits the filling of space by interpenetrating dodecahedra or icosahedra, and suggests that this might explain the growth of quasicrystals—metal alloy crystals showing five-fold symmetry.

The figure which Hecht describes as "two dodecahedroned," (20 dodecahedra interpenetrating in a periodically repeating lattice), in the process of growing into "three-dodecahedroned." Growth is occurring at lower right.



Laurence Hecht