21st CENTURY SCIENCE & TECHNOLOGY

SUMMER 2013 www.21stcenturysciencetech.com $10.00

Planetary Defense Update!

Locating Man's Identity

- Vernadsky and Astrobiology
- Humans to Mars?

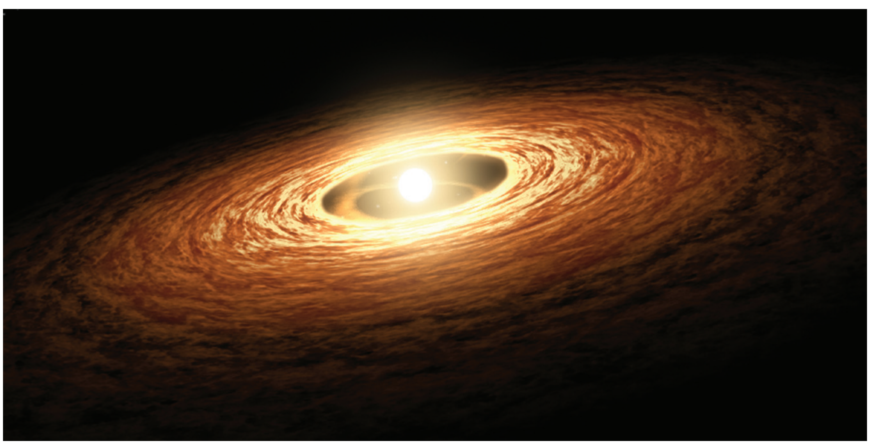
21st CENTURY
SCIENCE & TECHNOLOGY

Vol. 26, No. 2 Summer 2013

Features

News

Departments



On the Cover: This artist's concept shows a young sun-like star encircled by its planet-forming disk of gas and dust. Streams of material spiral from the disk onto the star. NASA/JPL-Caltech

21st CENTURY
SCIENCE & TECHNOLOGY

EDITORIAL STAFF

Editor-in-Chief
Jason Ross

Managing Editor
Marsha Freeman

Associate Editors
Elijah C. Boyd
David Cherry
Christine Craig
Liona Fan-Chiang
Colin M. Lowry
Gregory B. Murphy
Richard Sanders
Charles B. Stevens

Art Director
Alan Yue

Advertising Manager
Marsha Freeman

SCIENTIFIC ADVISORY BOARD
Francesco Celani, Ph.D.
Hugh W. Ellsaesser, Ph.D.
Lyndon H. LaRouche, Jr.
Wolfgang Lillge, M.D.
Ramtanu Maitra
Thomas E. Phipps, Jr., Ph.D.

21st Century Science & Technology (ISSN 0895-6820) is published 4 times a year by 21st Century Science Associates, 60 Sycolin Road, Suite 203, Leesburg, Va. 20175. Tel. (703) 777-6943.

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

21st Century is dedicated to the promotion of unending scientific progress, all directed to serve the proper common aims of mankind.

Opinions expressed in articles are not necessarily those of 21st Century Science Associates or the scientific advisory board.

We are not responsible for unsolicited manuscripts.

www.21stcenturysciencetech.com
Electronic subscriptions are $35 for 4 issues, $60 for 8 issues, and $80 for 12 issues. Back issues (1988-2005) are $10 each ($20 foreign). Electronic issues from 2006 on are $10 each.
Payments must be in U.S. currency.

© 2013
21st Century Science Associates

EDITORIAL

Reclaiming the 'Scientific Method'

by Jason Ross

While "scientific method" is a term we hear used all the time, and a much-trumpeted "scientific consensus" is cited as reason to move ahead with stunning reductions in carbon dioxide emissions to halt "climate change," a historical understanding of the development of science is scarcely to be found anywhere in the scientific community, let alone in the general population. We're told that the history of science belongs in the history department, and that education should focus on the most recent breakthroughs, rather than older discoveries that have been superseded. The problem is that along with the specific "back of the book" conclusions taught in today's classrooms, the concept of "scientific method" taught–that conclusions should be drawn from the results of experiments in which a hypothesized outcome is tested–leaves out the most crucial part of science! How are hypotheses formed? Which methods of thinking are fruitful at developing fundamentally new hypotheses, and which are not? Take for example, the founder of modern science, Johannes Kepler. How did he think?

Johannes Kepler

The astronomer Johannes Kepler overthrew the very concept of science. In his day, astronomical science was based on "saving appearances," meaning coming up with some sort of mathematical and geometrical model that matched observations. Whether or not the geometry the model was based on was *true*, was beside the point. Kepler insisted that the mind of man could understand the intentions of the Creator, the *reason* things were so, rather than otherwise. His physical theory of gravitation was shocking to his contemporaries, since it lay outside the entire domain of possible hypotheses (in their view).

If Kepler had simply presented his physical astronomy and associated laws of planetary motion, his discovery would have been divided in two by the astronomers of his time, into: 1) a mathematical means to compute planetary positions, which they would accept, and 2) a hypothesis of a physical cosmography, which they would feel free to reject or completely ignore, while using his mathematical apparatus. That is, astronomers would have completely ignored the kernel of Kepler's breakthrough, and treated his concepts as *additions* to science, rather than as requiring that all of science be rethought!

Thus, he was put in a position akin to that of the playwright: he had to communicate something to his audience in a way that would lead them to an understanding of his discovery, without leaving any opportunities to evade the full consequences of his new concept. Kepler required his audience to develop a new type of hypothesis-formation. The full consequences were not limited to the science of astronomy itself, but extended to the very nature of the physical universe, and how human minds could come to understand it.

To force this point, Kepler first demonstrated with absolute certainty that the problem could not be solved by geometry and mathematics alone. Using his *vicarious hypothesis*, Kepler made the best possible model based on mathematics, and showed that it could not work.[1] Here, an earlier example in his work, the *New Astronomy*, can begin to show the chasm that separated Kepler from his predecessors.

Helio-Centrism?

This example is the *mean sun*, an imaginary astronomical position near the actual Sun. This fictitious point was introduced by Ptolemy, whose thinking remained bounded within the possibilities of mathematical causes and effects, to coordinate the epicycles that he added to the orbits of the planets. Since, contrary to Ptolemy, our Earth does move, its changing position adds an extra element of *perceived* motion to the planets. Ptolemy kept the Earth still, and therefore had to add its motion to the other planets. He did this by incorporating circular epicycles into their orbits. Although the motion of these epicycles was coordinated with the Sun, which was known since the 2nd century BC not to appear to have a circular orbit, but an off-center one, Ptolemy wanted to use simple circles, and therefore introduced a (fake) perfectly circular solar orbit—the orbit of the *mean sun*.[2]

What was a mathematical shortcut for Ptolemy became an article of faith for those who came later. Nicolaus Copernicus, renowned as the man who set the Earth in motion around the Sun, did not place the Sun at the center of the cosmos. Instead, he used the same mean sun as had Ptolemy, which became, in Copernicus's system, the *center of the Earth's orbit*. Why would all the planets move around a point so near the Sun, rather than the Sun itself? How would they be affected by an imaginary point associated with just one of the many planets? Even Tycho Brahe, Kepler's sometime-employer, who had the planets circle the Sun which itself circled the Earth, also used the mean sun, rather than the real one.

Kepler insistently used the real Sun, as part of his absolute commitment to the truth. He wanted a real understanding, rather than a mathematical model that was "close enough." Since the Sun was the *reason* for the planets moving as they did, Kepler could not possibly replace it with a mathematical point. In Kepler's hypothesis, the planets went faster when nearer the Sun, not an imaginary point! Based on this physical foundation, he went on to discover the motions of each planet individually, as well as the cause for the relative distances and eccentricities of the planets, in his still-controversial work, the *Harmonice Mundi*.

End of the Road?

Kepler was committed to discovering causes for phenomena, rather than mathematical descriptions. This approach has been all but abandoned in modern science, particularly since the Copenhagen interpretation of quantum mechanics, which asserts that quantum phenomena cannot be known individually. Only when an experiment is repeated many times, can quantum mechanics indicate the statistics of what the outcomes will likely be. Causation in individual events no longer exists. Does this simply mean that the science is incomplete? Will quantum processes in life or the human brain, which expresses free will, allow more progress to be made?

No, its practitioners think we're at the end of the road. The Copenhagen interpretation has taken us back to pre-Keplerian thinking, where models to "save appearances" are considered all that is possible. Niels Bohr, the main proponent of this outlook, proclaimed his view of the new scientific method: "There is no quantum world. There is only an abstract quantum mechanical description. It is wrong to think that the task of physics is to find out how Nature *is*. Physics concerns what we can *say* about Nature."

Kepler would not agree with this! But, do we need a modern Kepler? Has the development of science brought us to the end of the road for methods of hypothesizing? How does the cultural and political environment affect the scientist? Two revolutions in scientific thought occurred a century ago: Einstein's relativity, and Planck's discovery of the quantum. Both discoveries required a reconceptualization of literally *everything*—nothing in physics was untouched, even if the changes were usually too small to be observed. These discoveries were not *additions* to knowledge in the usual sense of the word.

Einstein and Planck recognized the challenges to the concept of causation that their quantum revolution brought about. In the epilogue to Planck's *Where is Science Going*? the two thinkers express their thoughts. Planck:

"Where the discrepancy comes in today is not between nature and the concept of causality, but rather between the picture which we have made of nature and the realities in nature itself. Our picture is not in perfect accord with our observational results; and, as I have pointed out over and over again, it is the advancing business of science to bring about a finer accord here. I am convinced that the bringing about of that accord must take place, not in the re-

---

1. For more on the vicarious hypothesis, see *Metaphor, an Intermezzo* at http://larouchepac.com/metaphor-intermezzo.

2. See this author's guide to the *New Astronomy* at: science.larouchepac.com.

jection of causality, but in a greater enlargement of the formula and a refinement of it, so as to meet modern discoveries."

And Einstein:

"Our present rough way of applying the causal principle is quite superficial. We are like a child who judges a poem by the rhyme and knows nothing of the rhythmic pattern. Or we are like a juvenile learner at the piano, just relating one note to that which immediately precedes or follows. To an extent this may be very well when one is dealing with very simple and primitive compositions; but it will not do for the interpretation of a Bach fugue. Quantum physics has presented us with very complex processes and to meet them we must further enlarge and refine our concept of causality."

Where to, Now?

This issue of *21st Century Science and Technology* treats several subjects that have the potential to reveal new facts and provoke new ways of thinking that could fundamentally transform our notion of the scientific method. Academician Marov's paper on V. I. Vernadsky and astrobiology treats the scientific method of Vernadsky, the great Russian-Ukrainian scientist, and how his outlook is necessary today to make the needed breakthroughs in understanding life in the cosmos. Standing in opposition to the ability of the human species to change its relationship to nature in fundamental ways, Hans Joachim Schellnhuber, a top operative in Europe for "climate change" legislation, argues that the next breakthrough in science is to realize *the limits* of the mind, as discussed in the research report on his attempted re-appropriation of Vernadsky's legacy.

Space brings together the greatest challenges and potentials for science. Reports on recent conferences on "Humans 2 Mars" and planetary defense (as part of our ongoing coverage), reveal the potentials and limitations of current programs, and intriguing correlations between solar activity and earthquakes point to new connections to be drawn between the Earth and our entire Solar System.

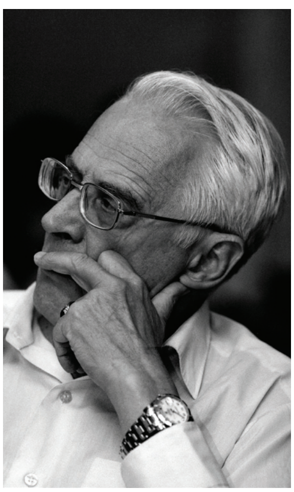
Vladimir Ivanovich Vernadsky: The Science of the Biosphere And Astrobiology

by Academician M. Ya. Marov

Figure 1
Schematic view of the Solar System and planetary nebula to be left behind after the Sun (a G2 star with the lifetime about 10 billion years) exhausts its nuclear fuel, approximately five billion years from now, according to the Encyclopedia of Astronomy and Astrophysics *(2002).*

V.I. Vernadsky's Biosphere

Vernadsky greatly expanded and developed the concept of the biosphere. He imbued that very word—first proposed by the French scientist Jean-Baptiste Lamarck in 1802, in his book *Hydrogeology*, to denote the totality of our planet's living organisms—with much deeper meaning. Now the term "biosphere" went far beyond its simple definition as the sum total of sedimentary rocks created by organisms, the sense in which it had been used in the late 19th century by the Austrian geologist Eduard Suess in *The Origin of the Alps,* and the German geologist Johannes Walther, well-known for his works on lithology. The term was understood in a new way after the 1926 publication of Vernadsky's *The Bio-*



Academician Marov is the head of the Department of Cosmochemistry, at the Russian Academy of Sciences' Vernadsky Institute of Geochemistry and Analytical Chemistry. His principal scientific interests have been in the fundamental problems of hydrodynamics, gas kinetics, and space physics, with an application to Solar System studies and planetary cosmogony. He has authored more than 250 technical articles, and 15 books and monographs. This is the second part of his paper, translated by William Jones, with Rachel Douglas and Susan Welsh.

In the first part, published in the Spring 2013 issue of 21st Century Science & Technology, *Academician Marov dealt with Vernadsky's career and with some of the important contributions he had made in the numerous fields in which he was engaged: mineralogy, hydrology, radiochemistry and biogeochemistry. But Vernadsky, Academician Marov noted, in his study of geochemistry and of life here on Earth always kept in view the cosmic dimensions of Earth's origin, and underlined the fact that the knowledge acquired in our examination of the Earth's biosphere would enable us to move forward as we cast our view to that broader Cosmos, in the study of life in the Universe in astrobiology, which he takes up in this issue.*

sphere; the body of his thought on the biosphere appeared most fully in the posthumously published books *The Chemical Structure of the Earth's Biosphere and Its Surroundings* (1965) and *Living Matter* (1978), in which were assembled some of his reflections and works on the subject that had not been published during his lifetime.

Vernadsky identified the boundaries of the biosphere as well as its composition, energetics, and dynamics. He included in the biosphere the upper part of the lithosphere to a depth of 2-3 km, which contains living bacteria, the hydrosphere, and the lower part of the atmosphere. Within the biosphere he distinguished two component types of matter: minerals, which he termed "inert," and living matter. The morphology of inert matter (its chemical composition and physical state) is preserved unchanged in the course of geological time, while living matter, both in totality and in its individual forms, undergoes continual change in the process of the biosphere's evolution as an integrated system. Vernadsky considered living matter, the active component of the biosphere, to be the carrier of free energy in the biosphere's geochemical processes, viewing certain forms of homogeneous living matter that have remained unchanged for billions of years (such as some species of *Radiolaria* that have been unchanged since the Algonkian Era, or the genus *Lingula*, unchanged since the Cambrian Era) as exceptions. At the same time, he rejected the existence of any special zones between living and non-living matter, advancing the empirical generalization that "there are no transitions between living and inert natural bodies of the biosphere: the boundary between them has been sharp and clear during the entire span of geological history. … Matter in the biosphere is comprised of two states, which differ materially and energetically—living and inert."

Vernadsky viewed the biosphere and the conditions under which life emerged on our planet as an inseparable component of a certain structure of the Earth's crust and its degree of organization. He based this conception on geology and geochemistry, and the tremendous amount of empirical material accumulated by these sciences. Geology had made it possible to formulate the scientific question of the origin of the biosphere, while geochemistry provided a reliable determination of the conditions necessary for the creation of the biosphere and the emergence of life. In his judgment, the task of geochemistry was the "study of the history of the chemical elements within the bounds of our planet," and this new branch of natural science was in fact established through Vernadsky's work. "We are obtaining a new and firm basis," he wrote, "resting on the tremendous amount of empirical material from geology and geochemistry. Geology now allows us scientifically to pose the question of the origin of the biosphere, and geochemistry to make a scientific determination of the conditions which life must satisfy in order for the biosphere to come into being." The emergence of the biosphere, therefore, is linked to a geochemically valid solution to the problem of the polyphyletic origin of the main taxa: that is, a close interrelationship among the diverse forms of primordial life, as a unified planetary phenomenon on the scale of the biosphere.

Vernadsky thought that the continuous migration of atoms in the Earth's crustal layer was biogenic to a significant degree, i.e., that it was caused by the geochemical energy of living matter (the energy of life), connected first and foremost with the processes of alimentation and respiration of living organisms. He came to the surprising conclusion that living matter changes the structure of inert matter, acting upon chemical compounds and even upon atomic states, and inducing a stable state of carbon in organic molecules under the thermodynamic conditions of the biosphere. Vernadsky thought that living organisms should be characterized quantitatively in the same way as other bodies, according to their atomic composition, mass, and energy, and that the mass of living matter and its average chemical composition in the biosphere are not changed or disrupted by the process of evolution. This approach to the biogeochemical function of the biosphere means that the biogenic migrations of atoms do not change either quantitatively or qualitatively, in spite of sharp changes in the morphological structure of living matter in the course of geological time. At the same time, the evolution of life forms results in an increase of geochemical energy and changes the character of the biosphere, particularly in connection with the "whirlwind of biogenic migration of atoms" resulting from the growth of civilization it has engendered, without, however, any noticeable violation of the regularities of the more powerful mechanism of the Earth's crust.

Solar and chemical energy serve as the original source of the energy of life. The absorption of solar energy by photoautotrophs—the living matter that uniquely transforms solar energy into chemical energy and distributes it throughout the planet—is one of the most important functions of living matter in the biosphere. And this is the basic energy source for exogenous geochemical and geological processes. In other words, living matter, transforming solar radiation, draws inorganic material into continuous circulation. This idea is central to the concept of biogeochemistry, which Vernadsky introduced. In it he included the functions of the exchange of matter—respiration, alimentation, creation of the body mass of organisms, their movements and the work they perform, and even grander undertakings on the scale of human communities. "Biogenic migration is of extraordinary importance in the structure of the biosphere," he wrote, "Suffice it to mention that the free oxygen on our planet is created almost entirely by the geochemical energy of life—by the photochemical processes of the plant world."

In his writings, Vernadsky repeatedly emphasized the biogenic nature of gaseous and liquid masses and their connection with living matter, which exerts a tremendous influence on the chemical composition of the atmosphere and hydrosphere. "Living organisms," he wrote, "determine by their life the chemistry of the sea, in particular the composition of seawater, and the character of natural waters—from freshwater, lake, and some mineral sources." This regulation is accomplished both by land-based living matter, which determines the chemical qualities of the river waters flowing into the ocean, and by marine living matter, which produces selective precipitation of the chemical elements which enter the ocean. In other words, the biogenic migration of the chemical elements on the Earth's surface in the biosphere has been accomplished with the direct participation of living matter throughout all geological time. Its manifestation within the mass of the planet's matter, like the phenomena of life, must increase in geometric progression.

Proceeding from the empirical generalizations of geochemistry, Vernadsky advanced three propositions, asserting that the existence of the biosphere and the appearance of living matter were inseparable. He believed that the biosphere was not an accidental formation, but rather a "distinctive lawful mechanism," whose individual parts are connected and mutually conditioned, and which has the property of being organized. Its state of organization is determined by biogenic cycles of the atoms of chemical elements, and not all of the elements are characterized by reversibility; some of them constantly exit from circulation. This thesis is extremely important, in that it precludes a chaotic state and proposes the self-regulation of the biosphere as a paradigm of the emergence of self-organization in the natural environment. It proposes the existence in the biosphere of orderly processes with historically developed forms of matter and energy transfer. And this means that it is possible in principle to describe the structure of living nature and its interaction processes with precision, on the basis of mathematical models. Another important proposition was his conception of the totality of all the organisms constituting life, as inseparable parts of this mechanism, which permeates the entire biosphere. Finally, he held that the basic features of the structure and mechanism of the interactions on which the biosphere is based were stable and constant, and that it had been a stable system in dynamic equilibrium over the billions of years since its origin, in the Archean Eon, similar to the stability and immutability of the configuration of the Solar System (Fig. 1). The absence of any restructuring of the biosphere, in the course of all geological time, essentially reflects "a scientific conception of the immutability and stability of all natural processes."

Closed biotic cycles, of which nutrient (trophic) interactions are an important component, are a condition for the stability of the biosphere and, at the same time, represent the basis of life as a biospheric process. Such processes as the growth of the biomass of organisms, the assimilation of matter, energy exchange, the differentiation/migration of the chemical elements, and the synthesis and breakdown of organic compounds at all stages of the trophic cycle in biocenoses, are all connected with these biotic cycles. The bacteria and plants of the early biosphere (the autotrophs) utilized carbon from atmospheric carbon dioxide and possessed no mechanism for nitrogen fixation or photosynthesis, nor did they have fermentation systems, which would have provided energy through the hydrolytic decomposition of their internal structures. These processes arose later in the course of evolution, and our modern animal world (heterotrophs), with its extraordinarily complex organization, consumes a wide array of organic and inorganic materials. Trophic relations essentially delimit the distribution and size of the population of any species, as well as its evolutionary development.

Vernadsky estimated the quantity of biomass at between one and ten thousand trillion tons, presuming that this has changed in the process of biological evolution together with the forms of life, starting from a tiny mass of blue-green algae and the first terrestrial plants in the Devonian period around 330 million years ago, through the greatly expanding mass of the Carboniferous swamp forests, and into the modern historical period. Vernadsky studied the geochemical energy of living matter, based on the quantitative patterns of its distribution in the biosphere and of the reproduction of various groups of organisms.

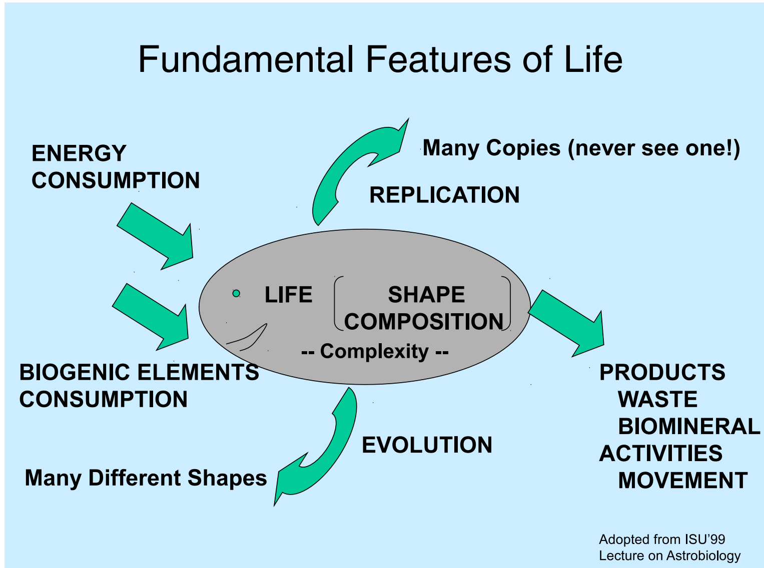
Comparing the energy balance of Earth with that of other planets of the Solar System, Vernadsky singled out the biosphere as the domain in which solar electromagnetic energy is transformed into mineral resources (which he called *solid solutions*) in the form of deposits of brown coal and hard coal, combustible shales, oil and gas, which are not found in the weathering crust or outside the biosphere. He estimated the magnitude of the energy of these combustible compounds—living matter of the Earth, produced solely by terrestrial vegetation—to be on the order of 10^{18}–10^{19} kcal. "Here we are dealing with a new process," Vernadsky wrote, "with the slow penetration of the radiant energy of the Sun, reaching the surface of the Earth, into the planet's interior. In this way, living matter changes the biosphere and the Earth's crust. It continually deposits in the Earth's crust a portion of the chemical elements that have passed through it, creating vast strata of vadose minerals,[1] unknown apart from living

1. Minerals enriched with manganese ("wad" or "bog manganese"). Vernadsky attributes great significance to the role of living matter and water in its concentration on the Earth's surface. In the geochemical history of manganese, biochemical reactions connected to bacteria

matter, or penetrating the inert matter of the biosphere with fine residual dust.” Vernadsky considered the stratified part of the Earth’s crust (the Earth’s sedimentary envelope) to be the remnant of earlier biospheres, and thought that even the granite-gneiss layer had been formed as a result of the metamorphism and remelting of rocks formed earlier under the influence of living matter. In other words, only basalts and the other main magmatic rocks are abyssal, their formation being unconnected to the biosphere. Insofar as life has never been present on the Moon or Venus, no granite-like rocks have been found there, but only the basic magmatic rocks.

Thus, Vernadsky’s biosphere is a global ecosystem in which connections among the gaseous, liquid, and solid envelopes are regulated by living matter, and the biosphere’s basic properties result from the activity of these envelopes. Life, therefore, is Earth’s planetary constant, which is closely bound up with the structure and the function of these envelopes. “Life is not . . . an external random occurrence on the surface of the Earth,” he said. “Never in all geological time have there been azoic[2] geological epochs.”

Figure 2



Schematic representation of the fundamental features of life.

Source: International Space University (ISU)

On the Origin of Life

We see that the very presence of living matter on Earth was Vernadsky’s starting point for developing his scientific conception of a biosphere literally permeated by everything living, and of the conditions under which the appearance of this matter on our planet became possible, although this intriguing problem itself—the question of the origin of life—remains unresolved to this day.

In his report “On the Conditions for the Appearance of Life on Earth,” presented in 1931 to the Leningrad Society of Naturalists and the Soviet Academy of Sciences, Vernadsky said:

> The conditions under which life appeared on our planet must be posed in realistic circumstances. Life is known to us, under real circumstances, only as an inseparable component of a certain structure of the Earth’s crust. One of the geospheres of our planet, the biosphere, is such a form of organization. The conditions that determined the first appearance of life on Earth are the same ones that determined the creation or origin of the biosphere on our planet. Scientifically, the question of the origin of life on Earth is therefore reduced to the question of the origin of the Earth’s biosphere. ... An organism removed from the biosphere is not something real, but rather an abstract logical construct.

In other words, life can arise only under certain physicochemical conditions, and the conditions that allowed for the appearance of life on Earth are those which led to the origin of the biosphere.

Life requires liquid water, the presence of biogenic elements, and available sources of free energy. Among the fundamental properties of life, distinguishing living from non-living matter, are the consumption of energy and natural substances, replication (reproduction), secretion of wastes, active biomineral exchange, and evolution (Fig. 2). The basic question we are addressing concerns the origin of life—the origin of the transition from prebiotic chemistry to the processes of metabolism, replication, and transmission of genetic information, since life in the modern sense has to be defined as a functional system, capable of processing and transmitting information on the molecular level.

Vernadsky’s view was that the main marker of the origin

play a major role, particularly autotrophic bacteria, which owe their existence to chemical energy (the energy of oxidation), and are capable of concentrating manganese to a level of 7%. More developed organisms (for instance, some marine plants, lichens, various fungi) concentrate manganese to a level of 1%.

2. Lacking life.

of life was the appearance in the biosphere of extremely diverse geochemical functionality, supplied by the totality of many species and various morphological classes of organisms, which could accomplish cyclical mass-exchange processes. "When we speak about the appearance of life on our planet, we are actually referring to nothing other than the formation of its biosphere," Vernadsky wrote. He formulated several important biogeochemical principles, according to which the biogenic migration of atoms of the chemical elements in the biosphere increases during the process of creation of stable life-forms, as these strive to maximize their manifestation. The evolution of species proceeds in the same direction. Throughout geological time, from the Cryptozoic Eon[3] onward, the process of populating the planet was necessarily the maximum possible for living matter, and never in the course of all geological time has there been a geological epoch without life. It follows that modern living matter has a permanent genetic link with that of preceding geological epochs. Obviously, while there has been no fundamental change in the geochemical influence of living matter on its environment, this does not mean that there is no process of evolution.

He viewed the biogeochemical functions of the biosphere, which provide the basis for life, as immutable, having existed continuously throughout geological time. Vernadsky included among these biogeochemical functions: gas exchange involving N_2-O_2-CO_2-CH_4-H_2-NH_3-H_2S, which is effected by all organisms; the oxygen function performed by photosynthetic plants; the oxidation and reduction functions, supplied primarily by bacteria, including autotrophic bacteria; the calcium function, carried out by algae, moss, and marine organisms, as well as by bacteria; and the concentration function, performed by unicellular and multi-cellular organisms. Biogeochemical functions are also responsible for the breakdown of organic compounds by bacteria and fungi, and for metabolism and respiration.

Vernadsky considered the biogeochemical energy of living matter to be based, above all, on the multiplication of organisms, caused by "their unremitting endeavor (determined by the energetics of the planet), to achieve a minimum of free energy," in conformity with the fundamental laws of thermodynamics, which are consistent with the conditions required for the existence and stability of the planet.

As we said above, viewing life as a planetary phenomenon, and all living organisms as an inseparable, lawful part of the biosphere, Vernadsky believed that life determines the chemistry, migration, and differentiation of the chemical elements. He thought that living matter encompasses and regulates all, or nearly all, the chemical elements in the biosphere, and that microorganisms play the primary role in these processes. "These are the most powerful biogenic planetary geological force, the most powerful manifestation of living matter," he wrote. And further on: "Life consists to a significant extent of the extraction of particular chemical elements from the environment, their filtration through the compounds or fluids of the organism, and their redischarge into the environment, often in the form of new compounds." The atomic ratios between calcium/magnesium, potassium/sodium, and other combinations, are transformed in the biosphere by the biogenic migration of chemical elements, which is accomplished by living organisms according to their various needs for particular elements.

According to Vernadsky, living matter differentiates not only chemical elements, but also individual isotopes, as has been experimentally proven for highly volatile ones—oxygen, nitrogen, hydrogen, and sulfur. In so doing, organisms, as a rule, selectively absorb primarily the light isotopes of these elements. Investigating the chemical composition of living matter, he distinguished four groups of organisms by their ability to concentrate one element or another. He called the simultaneous presence of chemical elements in an organism and in the Earth's crust "*organogenic paragenesis*," because it was caused not by the chemical properties of the elements, but by the properties of the organisms. These paragenetic associations of elements, created by living matter, are inherited in a different form by the biogenic component of the Earth's crust.

Vernadsky paid a great deal of attention to the question of the source of life's appearance on Earth. The theory that living beings originated from inorganic matter (abiogenesis) contradicted biogenesis, the theory of the "eternity of life," which is based on the principle *omne vivum ex vivo*, that is, that life arises only from life. This principle was established empirically in 1668 by the Italian scientist Francesco Redi, who demonstrated that fly larvae only develop in rotten meat when it contains eggs laid by flies. This was confirmed in the 18th century by the Italian scientist Lazzaro Spallanzani, who showed that microorganisms cannot develop in boiled broth. The decisive proof was provided in 1861 by the French scientist Louis Pasteur, whose experiments, like Redi's principle itself, did not deny, generally speaking, the possibility of abiogenesis in earlier geological periods as a special form acquired by matter at a certain stage of its development, but only indicated the limits within which abiogenesis does not occur. Nor did they contradict the cosmogenic hypothesis of the origin of life (panspermia), put forward at the end of the 19th century by Svante Arrhenius.

Vernadsky originally highly esteemed Redi's princi-

3. The Cryptozoic Eon is a now mostly obsolete synonym of the Precambrian Era.

ple, while later also conducting an in-depth study of the question of abiogenesis. He thought that notions about the beginning of life on Earth that were not connected with the planet's geological structure and history ran counter to accurate knowledge. This applied both to the possibility of the introduction of living matter to our planet from space, and to the possibility of life's having formed out of inert matter in a geologically ancient period of the Earth's history, through "spontaneous generation"—abiogenesis of one form or another, when natural conditions were radically different from today's. In the first case, one could assume that "life is just as much an eternal feature of the structure of the Universe, as are the atom and its aggregates" (and so the process may be ongoing even now), and that the conditions for life's origin in outer space involve processes not occurring on Earth, but that living organisms, when they fell to Earth, found favorable conditions here and were able to establish themselves. The second case assumes that there were physicochemical phenomena, conditions, and states on the surface of the young Earth that were conducive to and necessary for abiogenesis. The first primitive organisms to appear probably made use of basic organic substances such as monomers from non-biological sources, similar to what is occurring today in the Earth's deep biosphere.

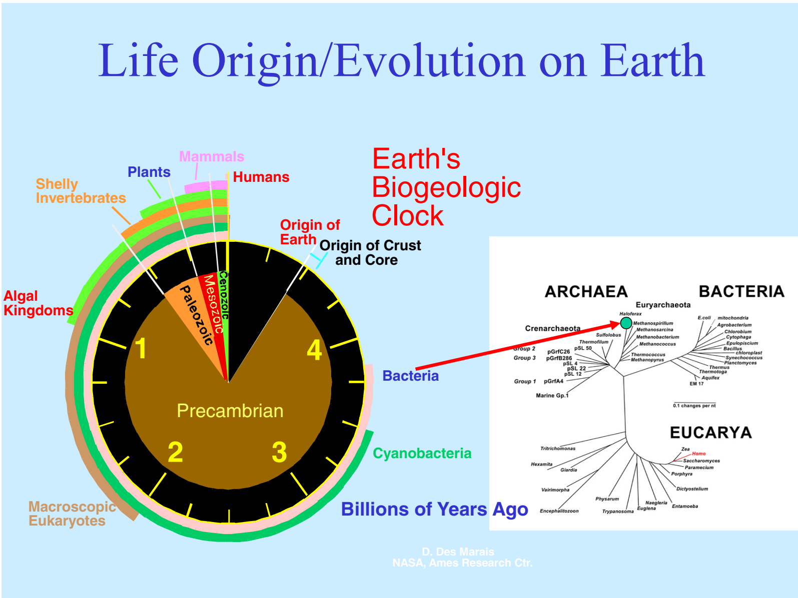
Vernadsky's conception was that, already in the early Archean, millions of open systems could have emerged on the basis of diverse primordial high-molecular-weight protein and nucleotide compounds. These systems would have been capable of remaining in a state of dynamic equilibrium for a certain time. The high degree of internal organization of some of these systems led to the appearance and persistence of metabolic processes and primitive replication, which served as the foundation of the incipient biosphere. The formation of the biosphere, in turn, launched the process of evolution and the creation of "morphologically different hereditary lines," in such a way that "the evolutionary process, in whichever of its forms we may consider, always occurs within the biosphere, that is, within living nature, and there can be no changes of the form of organisms outside of living nature." The physicochemical state of the biosphere, and its appearance, change in very close connection with the evolution of living forms: in the Precambrian, calcareous algae appeared; in the Cambrian, skeletal organisms; and in the Anthropogenic Era, man. The evolution of species becomes the evolution of the biosphere, while the geochemical energy of organisms should be seen as the effect of the action of a given species on its environment.

Studying the peculiarities of the space occupied by life, Vernadsky devoted much attention to the problem of dissymmetry, which, in contrast to classical symmetry, is characterized by the preponderance of left-handed or right-handed enantiomers. This phenomenon, which was discovered by Louis Pasteur and substantiated by Pierre Curie, is exclusively the property of living organisms and is absent in non-living nature. It was discovered that compounds concentrated in an egg or seed rotate the plane of polarization of light in a particular direction and such orientation is also present during crystallization of these compounds, as well as in organisms' ingestion of similarly oriented enantiomers and avoidance of different ones. Vernadsky regarded dissymmetry as a powerful factor in the selectivity and stability of life and thought that its genesis from inert matter, abiogenesis, could occur only in the peculiar environment of Earth, without cosmic factors playing a role. Vernadsky maintained that by studying this phenomenon, we penetrate more deeply, and in a new way, into the properties of the world around us than physics does. This fundamental property of life, the unidirectionality of biological molecules (left-handed L-amino acids and right-handed D-sugars), is now known as *chirality*.

In his discussions of the origin of life and the initial stages of the biosphere, Vernadsky above all strove to explain the markedly heterogeneous structure of the space of the biosphere, the profound physical distinction between the parts of the biosphere occupied by living organisms and the parts occupied by inert matter. On the basis of this conception, he ruled out the possibility of life's originating under isolated conditions such as, in particular, local processes of abiogenesis or the transmission to Earth of morphologically uniform organisms (for example, bacteria or algae) from which the millions of species of plants and animals would have emerged in the subsequent process of evolution. In his opinion, "a complex set of life forms must have appeared simultaneously, and then developed into today's living nature." Let us note that in his early works, Vernadsky expressed doubt that "all the diversity of organisms and complex living matter could have evolved from a few unicellular organisms that had settled on the Earth's surface from outer space." Later, however, he did not exclude the possibility of a cosmogenic origin of living matter, with its primitive forms having been brought to Earth in the very earliest stage of the planet's evolution. We find reference to this in the following statement: "The ability of unicellular organisms to perform in full all the geochemical functions of organisms in the biosphere makes it probable that they were the first appearance of life. For we now can trace the evolutionary creation of more complex organisms from simpler ancestors." It should be emphasized, once again, that this is a manifestation of the organized state of the biosphere through its biogeochemical functions.

At the same time, Vernadsky talked about directionality as a characteristic feature of the evolutionary process of

Figure 3



The evolution of life on Earth ("The biological clock of the Earth").

Source: D. Des Martis, NASA Ames Research Center.

life in the biosphere, which "is most intimately connected with the fundamental distinction between living matter and inert matter, and corresponds to the absolutely unique appearance in the biosphere of the energetic effect of the progress of life through time." Here we may note a direct link with thermodynamic irreversibility and Prigogine's notion of "the arrow of time."

There is still no consensus as to when and how life appeared on the young Earth. Vernadsky proceeded from the idea that the initial zones of life, and the biosphere, arose in the earliest geological epoch, that pre-biological evolution occurred very rapidly, and that the "field of life" has remained on the whole unchanged since the Archean Eon, as is indicated by the character and the paragenesis of the minerals forming the biosphere. Obviously this earliest stage of the biosphere included the abiogenetic synthesis of organic compounds and the matrix synthesis of macromolecules, followed by formation of the properties of metabolism, the mechanism of replication, and eventually the development of prokaryotes. Vernadsky considered as completely lawful the abiogenetic appearance of diverse life forms from inorganic substances, represented by the totality of many species, belonging morphologically to various sharply divided classes of organisms. This means that biocenoses must have developed immediately, although the subsequent evolutionary process was prolonged.

A number of investigators, following Vernadsky, think that the most primitive organisms, the eobionts, appeared on Earth 4.25 billion years ago, and that the emergence of photosynthesis in the prokaryotic protobionts dates from 3.5 to 4 billion years ago. This implies that the biosphere, populated by the eobionts, may have formed around 4 billion years ago and that the Earth's features took shape through an evolutionary process over the subsequent billions of years, in which life had emerged, and the biogenic migration of atoms played a decisive role (see Fig. 3).

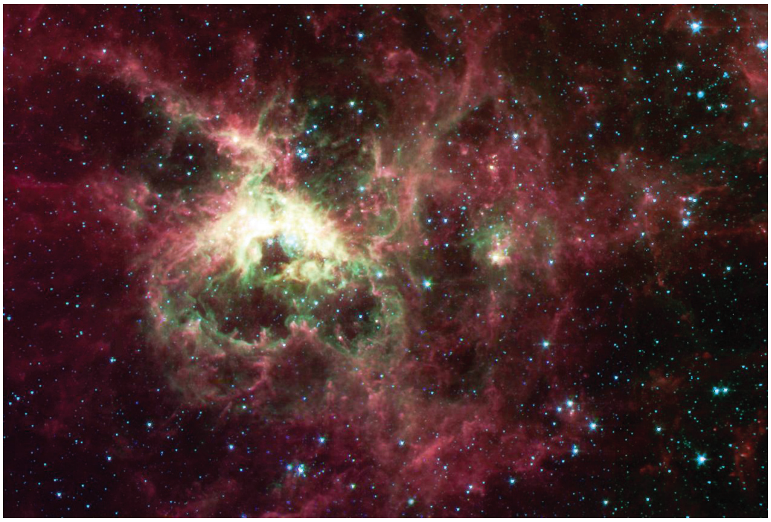
Thus a geochemical approach to the study of life gives us a better understanding of the peculiarities of its emergence and the way in which organisms act on their environment, as well as allowing us to formulate the conditions necessary for life to appear. This, in turn, imposes limits upon our conceptual models of forms in which either abiogenesis or the introduction of life from outer space might have occurred. In any case, the structure and properties of the space occupied by life (the biosphere, as distinct from other geospheres) had to have changed, and diverse special biogeochemical functions must have appeared. The latter were brought about by living organisms and are the functions of a single, indivisible set of organisms, a set comprised of the numerous morphologically diverse forms that cause the complexity of life.

The Connection with Astrobiology

V.I. Vernadsky's fundamental ideas about the biosphere and its indissoluble connection with the origin and evolution of life have remained fully relevant as decades pass. Impressive results have been achieved in the approach to the most difficult problem, the origin of life. At the same time, it has been realized that the phenomenon of life itself cannot be viewed in isolation, without reference to numerous factors that exist in the Cosmos; this has reinforced Vernadsky's concept of the evolution of the Earth as a combination of cosmic, geological, and biogenic processes. This is how astrobiology came into being, first of all as a framework for the attempt to uncover these relationships and to understand the phenomenon of life and how it arose on our planet, and then also to detect signs of life in the Solar System and beyond.

The chemical evolution of matter in outer space, which is the subject of astrochemistry, is an important aspect of the origin of life. Organic synthesis, a process that takes no more than a thousand years, occurs in the interstellar

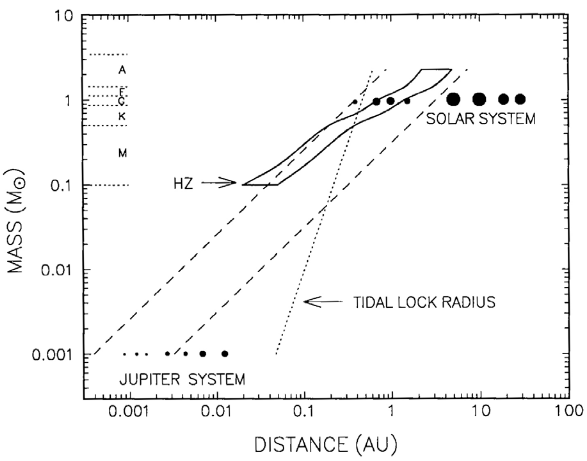
Figure 4



An example of a molecular cloud (Tarantula Nebula), in which star formation occurs.

Source: NASA, Spitzer Space Telescope

Figure 5



A habitable zone for planets in the vicinity of a mother star (the distribution of the sphere of the habitable zone). The vertical axis indicates the spectral class and the mass of the star relative to the mass of the Sun. The horizontal axis gives distance in astronomical units. The dashed lines show the boundary limits for the planets depending upon the star class and the radial distance, and the dotted line shows the tidal lock radius. Theoretically, three planets of our Solar System exist within the boundary of the habitable zone: Earth, Venus, and Mars.

Source: J.F. Kasting, D.P. Whitmire, R.T. Reynolds. "Habitable Zones Around Main Sequence Stars" *Icarus* **101**:108-128 (1993)

medium. Synthesis is particularly efficient in interstellar molecular clouds of gas and dust (Fig. 4), where it is fostered by the turbulence and evaporation of particles in the cloud. More than 200 fairly complex organic molecules have been found in molecular clouds, including a large quantity of hydrocarbons (building blocks of the polycyclic aromatic hydrocarbons, PAH), the simplest of which is benzene. About 70 amino acids were discovered in the Murchison and Murray meteorites, a finding which supports models of the extraterrestrial origin of the precursors of biomolecules.

In discussing the origin of and search for life, the biological mechanism of life on Earth is naturally our primary point of reference. Of course, the natural conditions on the planet that were necessary for prebiotic evolution and the origin of life are of paramount importance, and Vernadsky paid them special attention. Life as we know it can exist only in a very limited range of natural conditions. In other words, from the outset there are fairly strict limitations on the mechanical and thermodynamic parameters of a celestial body on which life might come into being. A planet suitable for habitation must meet well-defined criteria, including size and mass, since a large planet accretes material until it becomes a gas giant, while a small planet loses its atmosphere; temperature and pressure allowing for the presence of liquid water; the existence of an atmosphere with a suitable chemical composition, excluding aggressive impurities; a radial distance from the parent star that makes favorable climatic conditions possible; and an optimal distance from the parent star, because a planet that is too close is locked in tidal resonance not favorable for the development of life (Fig. 5). Meanwhile, based on our terrestrial experience, we should also keep in mind a number of favorable circumstances for the origin, support, proliferation and detection of life. Indeed, with respect to metabolism (respiration, alimentation) life has great variety and adaptability, and living organisms are able to withstand extremely harsh environmental conditions (a wide range of temperatures, low pH), and the ingredients necessary for life are widely distributed (see Figs. 6,7). It is no accident that Vernadsky, based on what was known in his day, supposed that life might exist on Venus, Mars, and even Jupiter and Saturn.

Now we know that in the Solar System, the habitable zone, within which a planet could theoretically support a climate favorable to the emergence and continued existence of life, is near Earth's orbit, coming far short of

(a)

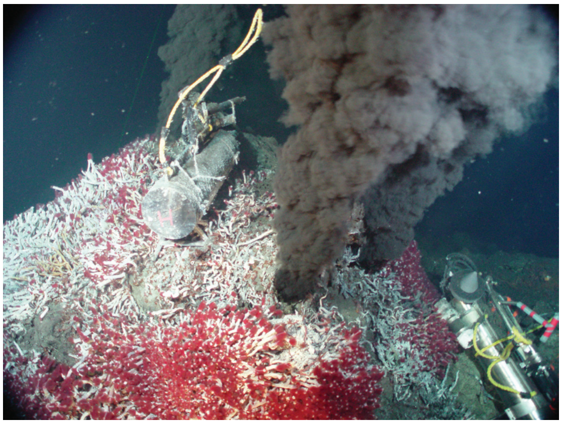
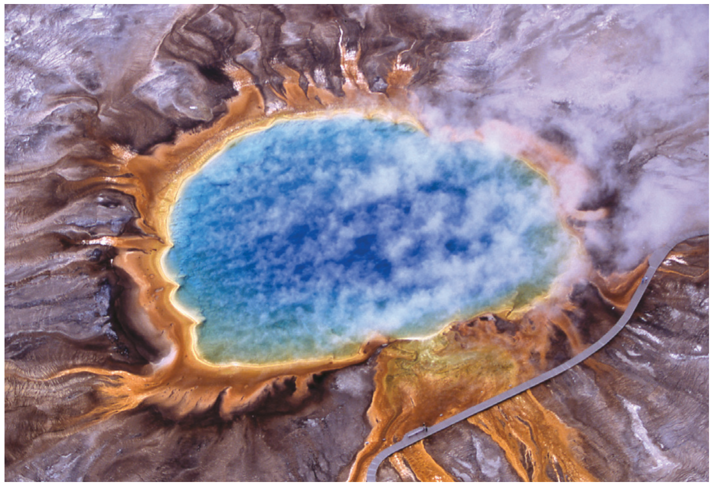


Figure 6

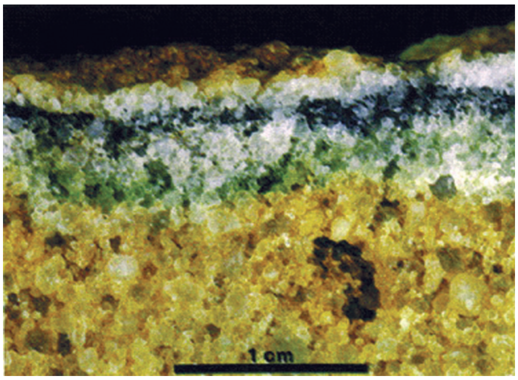
Life is hardy. Microbial life (extremophiles) are found near undersea volcanic vents, in deep underground aquifers (a), within rocks (b), or in hot (120ºC) acid lakes (c). Cyanobacteria fossils from 650 million years ago (d). The existence of these bacteria suggests that life needs only water, a source of energy, and cosmically abundant elements.

Source: NOAA PMEL Vents Program, ISU, NPS

(c)



(b)



(d)

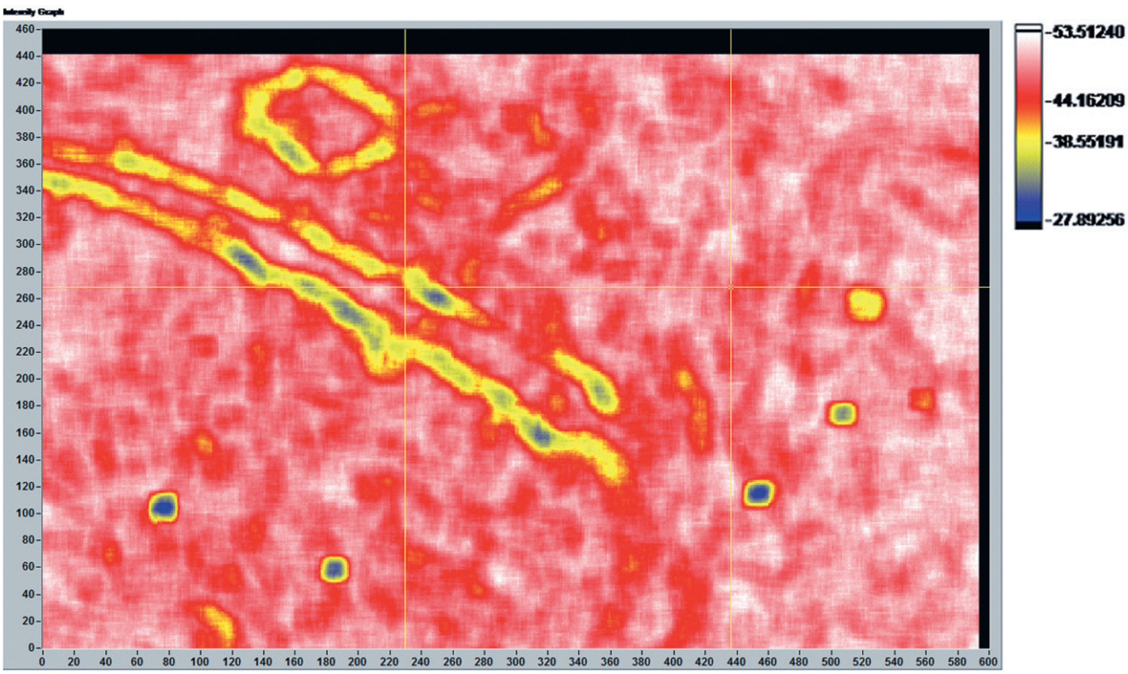
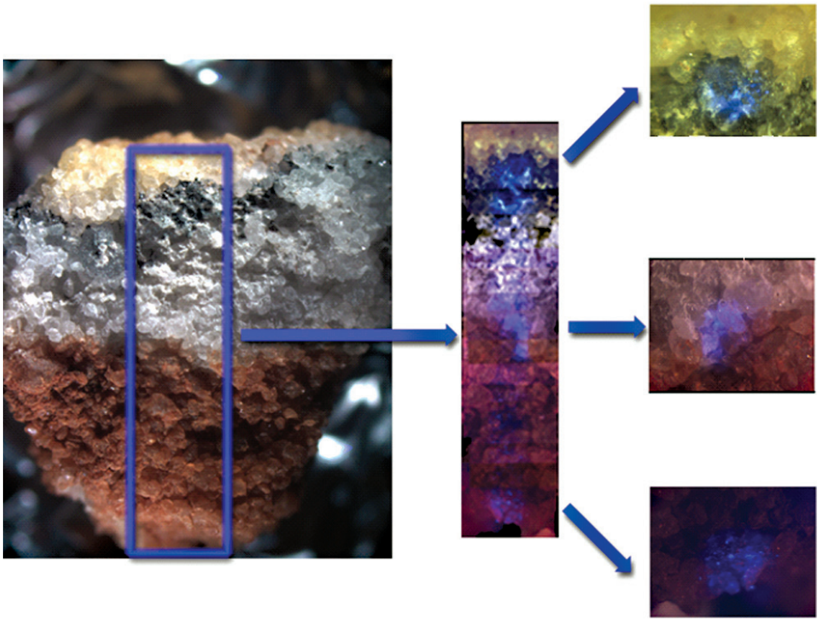


Figure 7



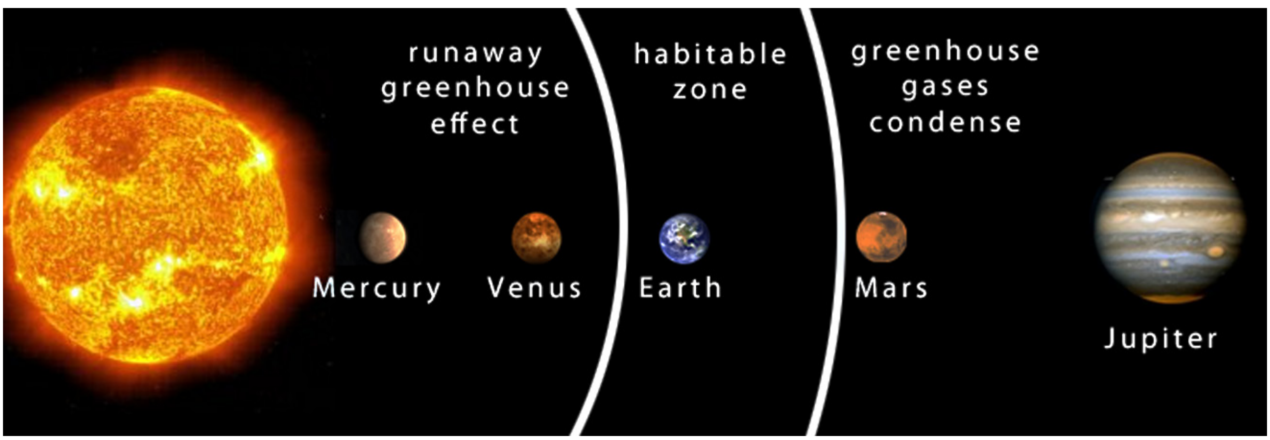
Antarctic dry valley cryptoendolithic community, visible light and deep UV (224 nm) images.

Source: Center for Life Detection, JPL/CIT

the orbit of Venus, and only approaching the orbit of Mars (Fig. 8). Unfortunately, we cannot yet answer the question of what distinguished Earth from the other planets in the Solar System, making the emergence of the biosphere possible here. On Venus (Fig. 9), this possibility is excluded by the runaway greenhouse effect, which has raised its surface temperature to 475° C and its pressure to 90 atmospheres. At the same time, there is reason to believe that in the early Noachian Era favorable climatic conditions for life to arise existed on Mars, including quite deep water oceans. The climate changed catastrophically about 3.6 billion years ago, leaving a waterless desert surface and a rarefied atmosphere (Fig. 10), but traces of primitive Martian life may have survived. It is not impossible that life may exist in what are assumed to be oceans of water under the icy surface of two of the Galilean moons of Jupiter, Europa and Ganymede (Fig. 11). The evolution of organic material on Titan, a satellite of Saturn (Fig. 12) is a question of great interest. Recently, researchers' attention has been increasingly attracted to exoplanets, especially the Earth-like planets that have already been discovered in orbit around other stars, and also to the prospect of finding life on them, the more so since the impact of life on the environment is rather noticeable and lends itself to external observation.

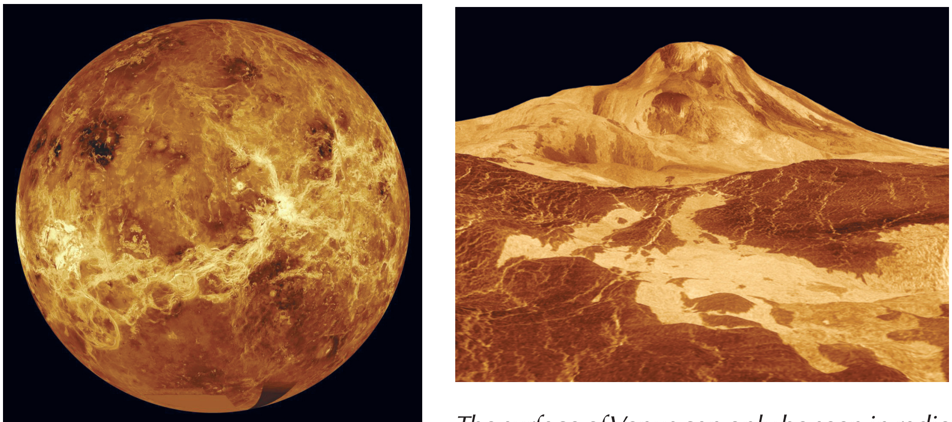
Among the astronomical aspects of the origin of life, the connection of the biochemical evolution of matter with cosmic factors merits attention. As discussed above, Vernadsky repeatedly turned to the choice between alternative models of the origin of life and the biosphere: directly on Earth, or with an external cosmogenic source

Figure 8



The actual habitable zone in the vicinity of Earth.

Figure 9
Images of Venus

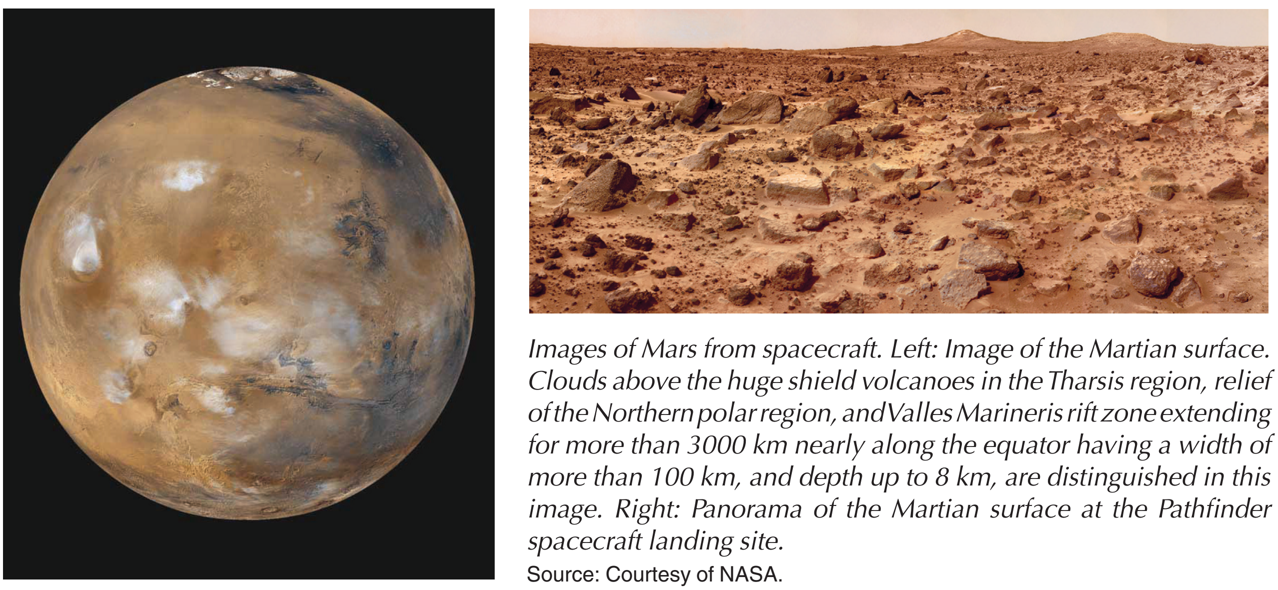


The surface of Venus can only be seen in radio wavelengths, which are transparent to the thick atmosphere and clouds. Radio mapping has revealed many relief features and peculiarities of the Venusian surface. Left: Mosaic of images of the surface returned by the Magellan spacecraft; more or less ordered structures can be distinguished in the chaotic pattern of the relief. Right: Evidence of volcanic activity. An image of the surface outpouring of volcanic lava ("pancakes") in perspective projection from the radar mapping of Venus from the Magellan spacecraft.
Source: Courtesy of NASA.

from the primary asteroid belt and from the trans-Neptunian Kuiper Belt (Fig. 13). Carbonaceous chondrites are the key to finding extraterrestrial sources of organic matter: they contain chemically bound water and their parent bodies (hydrosilicates) were probably formed in water. Comets enriched with water and carbon are even more prolific carriers of the seeds of life. Indeed, the ratio between the carbon in comets and the carbon in carbonaceous chondrites is 10:1, although the meteorites' volatile organics might have been lost at later stages during asteroid impacts. Given the key role of water in the origin of playing a part. Our modern understanding of the important role of matter transport and of migration and collision processes in the Solar System, in which the key role is played by comets and asteroids with a carbonaceous chondrite composition, allows us to consider these small bodies as likely carriers of prebiotic or even biotic matter life, it is important to note that modeling has indicated that the Earth could have received a large influx of volatile matter from comet and asteroid bombardment, including a quantity of water comparable to the volume of our planet's oceans.

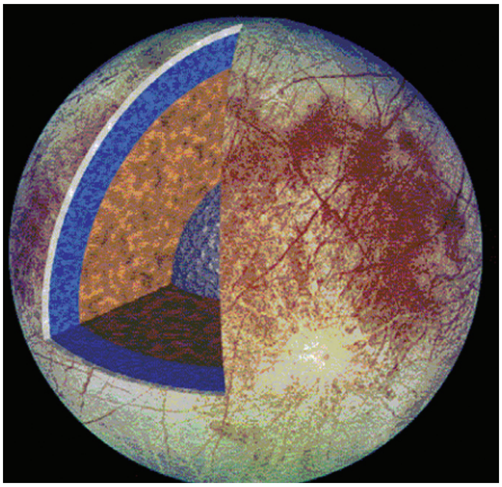
Of course, the question of how life originated is of

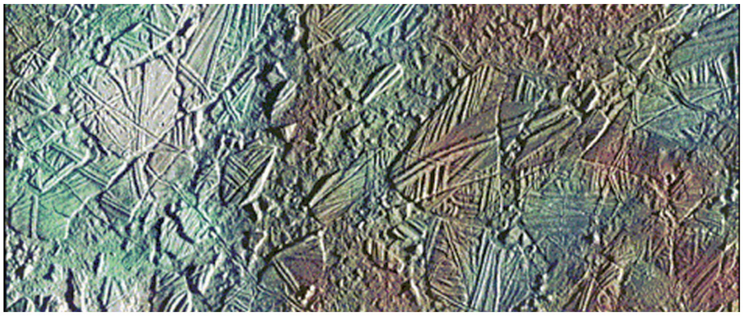
Figure 10



Images of Mars from spacecraft. Left: Image of the Martian surface. Clouds above the huge shield volcanoes in the Tharsis region, relief of the Northern polar region, and Valles Marineris rift zone extending for more than 3000 km nearly along the equator having a width of more than 100 km, and depth up to 8 km, are distinguished in this image. Right: Panorama of the Martian surface at the Pathfinder spacecraft landing site.
Source: Courtesy of NASA.

Figure 11





Left: Jupiter's Galilean satellite Europa. The surface is crisscrossed by ridges, troughs, and faults whose relief does not exceed several hundred meters in height. The absence of craters is indicative of a young surface. The present-day model of Europa's internal structure assumes there is a water ocean ~50 -100 km in depth under a relatively thin ice crust ~10 -15 km in thickness and a silicate mantle and a core composed of rocks lie below it. Right: A 70 km x 30 km area of Europa's surface (the Conamara region). The colors are enhanced to emphasize the relief features; the Sun is on the right. The white and blue regions correspond to a fresh surface partially covered with dust, while the brown ones probably owe their origin to mineral deposits. The areas ~10 km in size bear the traces of displacements of the upper ice crust layer, which can be associated with the presence of water or soft ice at a comparatively small depth.

Source: Images from Galileo spacecraft, courtesy of NASA.

paramount interest. When we talk about the origin of life, we are dealing not only with the formation of chains of nucleotides and amino acids (nucleic acids and peptides), which constitute the informational (DNA and RNA)[4] and the functional (proteins) basis of life, respectively, but also with the formation of the first ecosystem. Among the various conceptual approaches to the origin of life, the most noteworthy and well-founded, in our view, are the hypotheses of an ancient RNA world and of a sequential ordering process, developed by the author's colleagues A.S. Spirin and E.M. Galimov, respectively. In each of these, processes of biochemical evolution are crucial. As for Darwinism, it has an important role with regard to the stages of biological evolution, but not at the early stages of life's coming into being and the development of the molecular mechanisms of biological systems. From this perspective, molecular

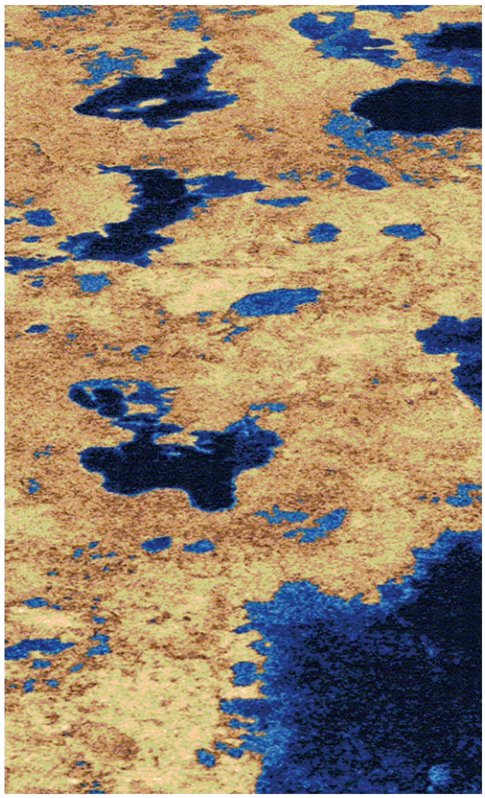


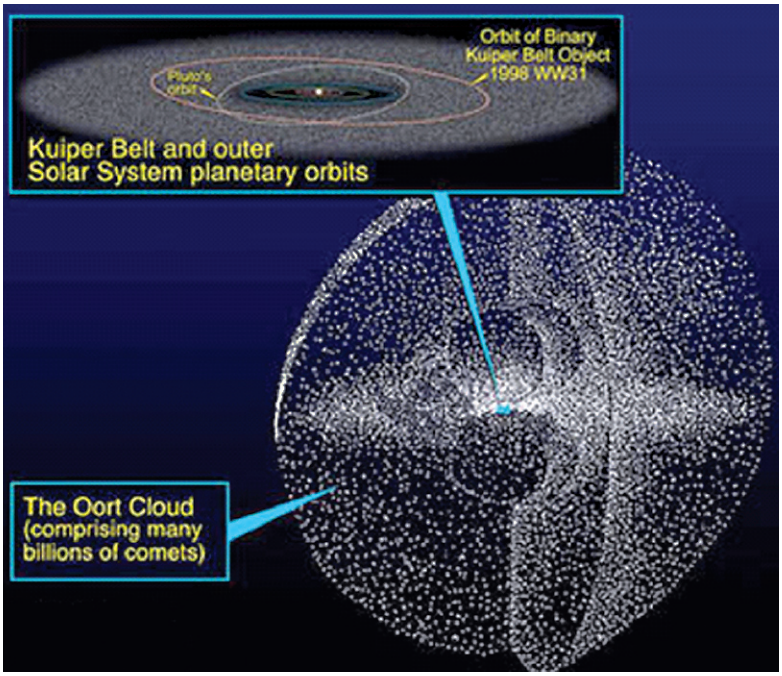
Figure 12

The surface of Saturn's satellite Titan. The dark spots on the lighter surface composed of water and hydrocarbon ices are associated with methane lakes, which corroborates the hypothesis about the existence of a methane cycle between the surface and the atmosphere.

Source: Images from the Huygens lander, courtesy of ESA.

4. We note that only about 5% of the double DNA spiral is used for coding, while the remainder contains information on how the sequence of genes is to be ordered.

Figure 13



Left: The Oort cloud and the Kuiper Belt. The Kuiper Belt located at the outskirts of our planetary system (40-100 AU) lies deep inside the Oort cloud whose outer boundary is at a distance of 104 – 105 AU. Right: Image of Hale-Bopp comet during its encounter with the Sun. A small nucleus (~10 km) is hidden deep inside a bright region, the coma (cometary atmosphere) tens of thousands of kilometers across produced by the sublimation of gas and dust from the icy surface of the nucleus. Extended type I and II tails are clearly seen.

Source: NASA

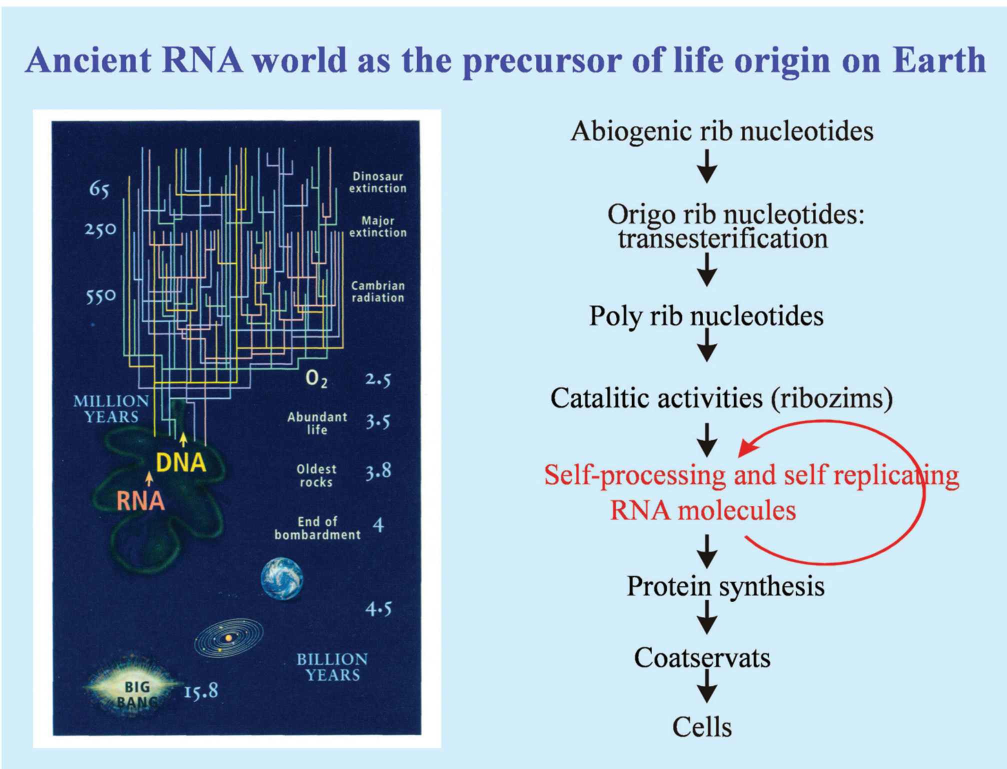


Figure 14

Left: A chronology of events in the course of the evolution of the biosphere. Right: A schematic depiction of the evolution of life from its origin in the ancient RNA world.

Source: J.F. Atkins and R.F. Gesteland; A.S. Spirin.

genetics, biochemistry, and Darwinism are complementary, and constitute the foundation of modern evolutionary theory.

An Ancient RNA World

Among the arguments in favor of the concept of an ancient RNA world, as the basis for the evolution of the primal biosphere, are the unique properties of the RNA molecule (a three-dimensional heteropolymer) defined by the sequences of RNA bases along the strands and the character of the coiling. Indeed, ensembles of RNA molecules carry out the functions of assimilation, metabolism, and replication. It is important to emphasize that RNA may contain genetic information or serve as a temporary copy of genetic information. For this purpose it uses a short-lived intermediate molecule (mRNA), which carries the initial information for production of a specific protein and copies the cell genome—DNA. Thus, RNA has the ability to perform many of the basic functions of DNA, participating in the ribosome's process of protein synthesis. These include encoding—programming the synthesis of biopolymers by a linear sequence of polynucleotides; replication—strict copying of genetic material; the self-folding of linear polynucleotides into unique compact configurations (3D structures); recognition—specific interaction with other macromolecules; and catalytic functions. To this list should be added the fact that an RNA molecule has transfer properties (tRNA); that is, it transports other molecules that are necessary for a number of biological reactions and for protein synthesis. Each of the 20 existing tRNA molecules can attach to only one of the 20 amino acids, which it transports to a certain ribosome and then integrates into the chain of protein being synthesized, in accordance with the specifications contained in the intermediate mRNA molecule.

Then there are catalytic RNA molecules (ribozymes), which are involved in protein synthesis, along with standard protein catalysts (enzymes). These ensure the selection of specific intermolecular reactions and reduce the amount of energy they require. In addition, ribozymes provide the correct arrangement of nucleotide bonds in the chain during splicing of the mRNA molecules; only after this will they be read correctly by the ribosome in protein synthesis. Thus ribosomal RNA molecules (rRNA) play a very important role in protein synthesis, because they form the structural core of the ribosome, consisting of more than 50 different proteins and several rRNA. The ribosome, in a sense, "relies on" the catalytic functions of the rRNA during protein synthesis, and by reading the information encoded in the mRNA, it "knows" which protein to make. However, the extremely complex mechanism by which the genetic information of nucleic acids is decoded into the structural parameters of proteins, and how this mechanism was formed in the process of evolution, is not yet fully understood.

It follows from what we have said here that RNA, as the working instrument of cellular production, could have been the prototype of living systems. However, the emergence of an RNA world and its evolution up to the point of the first highly organized organisms—bacteria—over an extremely short period of time (about the first half-billion years in the Earth's history) is unlikely, as advocates of this concept themselves admit. This difficulty may be eliminated by adducing a hypothesis that ensembles of RNA molecules originated and underwent their initial evolution in the environment of outer space, especially on small bodies such as comets, which bombarded the Earth and other planets intensively about 4 billion years ago. Therefore the idea of an ancient RNA world is linked with the possibility of the extraterrestrial origin of life.

A Sequential Ordering

An alternative to the conception of an ancient RNA world is that of a sequential ordering of the processes of the origin and early evolution of living matter as the chemical basis of life. This approach is consonant with Vernadsky's ideas about processes of abiogenesis in open systems that have a high degree of internal organization and are capable of remaining in a state of dynamic equilibrium for some time, and about the organized nature of the biosphere, based on the biogenic cycles of the atoms of chemical elements, which preclude a chaotic state. As part of this concept, in which the basic functions of RNA molecules also play an important role, as mentioned above, the origin of life is conceived of as a continuous ordering process in an open stationary system, which, in contrast to a conservative (Hamiltonian) system, which conserves energy, is a dissipative system that exchanges energy with the environment. Such a system would consist of prebiotic organic compounds that had emerged in the process of chemical evolution, possibly having originated in outer space. Conjugated chemical reactions occur in the system, producing not only positive but also negative entropy, which is a necessary condition for structural organization (ordering) in a chaotic environment. The energy is thereby maintained above a certain minimum level, as long as Prigogine's minimum entropy production conditions are met.

Chemical ordering (limitation of the number of partners in a reaction, and the number of mechanisms and interaction paths) is implemented efficiently by selective catalysis employing biochemical catalysts—enzymes, which are peptide chains (proteins) folded into three-dimensional structures; these are highly active and they efficiently accomplish the ordering by means of selective catalysis. According to Galimov, the adenosine triphosphate (ATP) molecule, which consists of adenine, ribose, and a phosphate group, could play a key role in these processes. It absorbs solar energy and transfers it to the conjugated chemical system, and the universal mediator for coupling is water (hydrolysis). An appealing factor here is that ATP is synthesized from simple molecules, hydrogen cyanide (HCN) and formaldehyde (HCHO), which are widespread in outer space.

However, unlike Galimov, who assumes linear processes of increasing complexity in the above concept, the author believes that the accumulation of changes occurs in a highly nonlinear system, which leads to instability, bifurcations (discontinuities), and successive transformations of the system into a qualitatively new state. In mathematical language, such a process corresponds to the branching (qualitative change) of solutions under certain (critical) parameter values. For each new state (self-organization) of the system there is a different corresponding set of interactions of the molecular complexes. In other words, the increasing ordering of the original (chaotic) system takes the form of a sequence of bifurcations, from the appearance of primitive polymer structures and the development of the universal catalytic function of peptides, to the emergence of the nucleotide sequences involved in protein synthesis, and the genetic code in which the general plan of organism development as well as its numerous individual peculiarities are recorded.

From the standpoint of stochastic dynamics that we are developing, such events are nothing other than the outcome and consequence of local instability in a nonlinear chaotic dissipative system with many degrees of freedom, while the sequence of changes in state (evolution) of the system leads to self-organization. The sequential-ordering model furthermore requires, as an important property, that there be feedback for the transition to a new level of organization. A reducing medium is also required under conditions of the separate existence of an atmosphere and a hydrosphere, as well as the accessibility and mobility of phosphates, which generally is not inconsistent with current ideas about the natural conditions on Earth at the time of the appearance of the first primitive forms of life.

According to this concept, the capability of ordering through selective catalysis and the capability of self-reproduction are the two most important properties of bioorganic compounds, necessary for the origin and evolution of life. The initial ordering is created by nucleotide chains and amino acid chains (peptides). Chains of amino acids form the universal design of biological structures capable of infinite variety, and chains of nucleotides provide for self-reproduction (replication) as a fundamental property of living matter. In other words, between these two classes of organic compounds, nature has divided up: the tendency toward ordering through selective catalysis, and the capacity for self-reproduction.

It is of particular note that in the world of organic compounds, ordering is effected by the unique properties of carbon compounds. Only on the basis of carbon can complex biopolymer structures be created, and ordering through selective (enzymatic) catalysis and replication (self-reproduction) take place. This statement should be considered as the main paradigm of the origin of life. Therefore, the discussions sometimes encountered about the possibility of life existing on the basis of silicon, for example, are groundless. If there is life in the Universe, its molecular construction is probably analogous to that of life on Earth—that is, based on carbon and its compounds, and on principles that allow a protein-nucleotide form of functioning.

Evolution

We shall now briefly touch upon the issue of biological evolution. The formation of biopolymers capable of catalysis and replication includes the appearance of an intermediary between peptides and nucleotides, such as the above-mentioned transfer RNA (tRNA); it also includes the formation of the genetic code. The emergence of the genetic code completes the stage of prebiotic evolution, and biological evolution itself begins (the evolution of life). As we said above, Vernadsky reasonably thought that one of its fundamental properties was dissymmetry, or chirality.

Biological evolution is understood as cumulative changes over time. Through a continuously increasing state of order (including RNA precursors), one believes that the first living organisms appeared on Earth approximately 3.8 billion years ago. These were bacteria with complex molecular apparatuses for heredity, protein synthesis, energy supply, and metabolism. The emergence of the first living systems (prokaryotes, eukaryotes) was accompanied by evolution on the level of cells,[5] organisms, and ecosystems, and the formation of what Vernadsky saw as the biosphere. As this occurred, the ordering processes were inevitably accompanied by processes of disorder and chaos. In the competitive processes of ordering/disordering (degradation), Darwinian natural selection played a decisive role.[6] Thus we emphasize again the important role of Darwinism in biological evolution, but not at the early stages of the establishment of life and the development of the molecular

5. Here we should emphasize again the striking self-organization of living species on the cellular level involving a well-controlled and coherent sequence mechanism of turning on and off specific groups of genes in the different cells.

6. It is worth noting that natural selection is responsible for the elimination of the dominant part of mutations harmful to life; their carriers fail to survive or leave behind posterity.

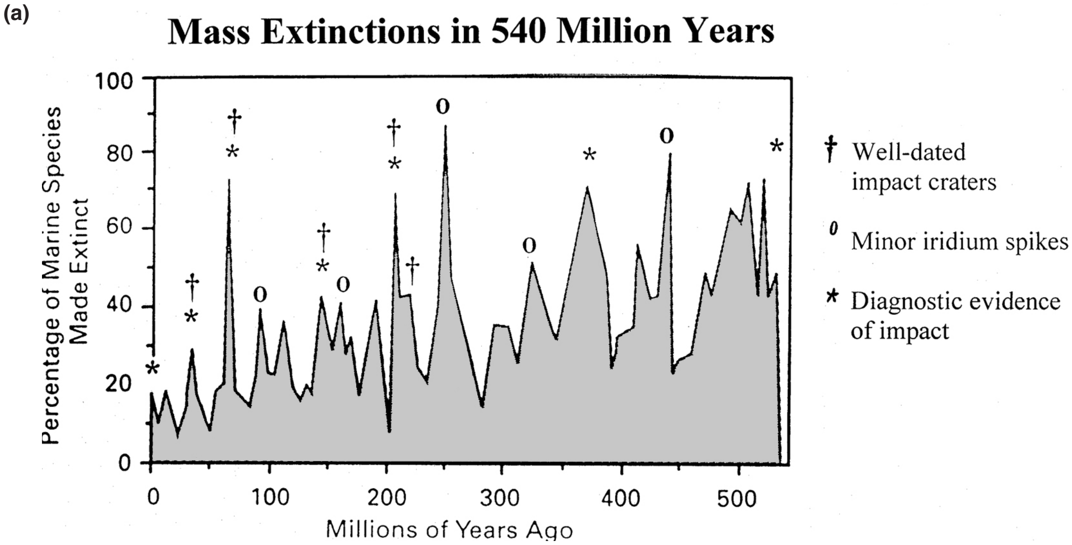
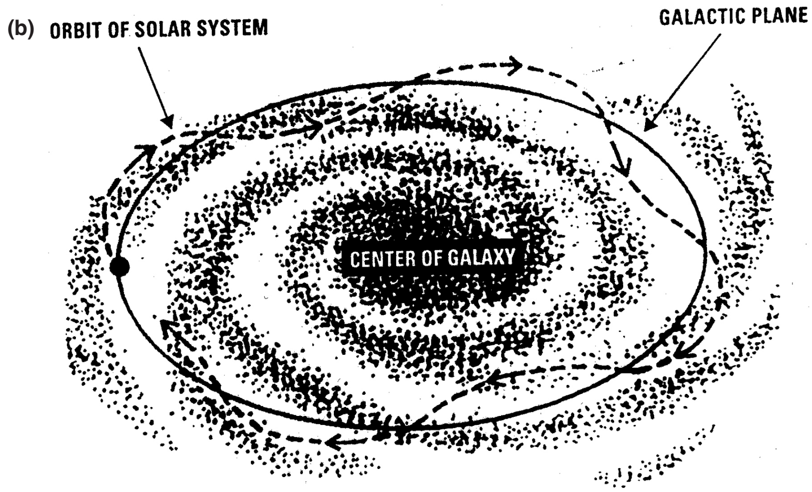


Figure 15
Above: The mass extinctions of living organisms on Earth during the last 540 million years. The events correspond to impact craters, enriched with iridium and containing other signs of falling cosmic bodies. Right: Schematic view of the movement of the Solar System through our galaxy.



self-organization mechanisms of biological systems. We emphasize once again that from this perspective, molecular biology, biochemical genetics, and Darwinism are not contradictory, but rather complementary and quite coherent foundations of modern evolutionary theory. Darwinism may be further developed through the concept of "covariant reduplication," proposed by the highly regarded Russian scientist N.V. Timofeyev-Resovsky,[7] which is based on the idea of matrix reproduction and replication of different variants of genetic texts, including those which have undergone mutation, followed by these versions being "offered" to nature to choose from. This concept is closely related to Vernadsky's ideas, discussed above, about the matrix synthesis of organic macromolecules during the evolution of the biosphere. Accordingly, the matrix mechanism of variation and heredity is associated with natural selection and the theory of evolution.

The Connection to Philosophy

We encounter highly relevant philosophical considerations in Vernadsky's manifold scientific legacy. Here we shall briefly touch upon only a few issues that are directly related to his scientific conceptions of the biosphere and the origin of life, while they also extend to pressing global problems for mankind.

A distinctive feature of all his creative work was his ability to see beyond the particular to the general, and, by analyzing actual data, to arrive at philosophical conclusions and generalizations, although he considered himself a philosophical skeptic. The basis for this view was his conviction that "no single philosophical system. . . is capable of achieving that general validity which science achieves (and only in some specific instances)."

7. Also written "Timofeev-Ressovsky."

He was critical of all philosophical systems, always adhering to his chief postulate: "All scientific work rests on the foundation of a uniform axiomatic assumption that the object of scientific study is real—that the Universe is real and it is lawful; that is, that it can be comprehended by scientific thought." He considered only the scientific outlook to be "an expression of the human spirit," while acknowledging that science is to some extent nourished by ideas and concepts which originate in the domain of religion and philosophy. In his article "On the Scientific World Outlook," he wrote that "the boundary between philosophy and science with regard to the objects of their investigation disappears, when it comes to general questions of natural science." Moreover, it is possible to formulate general laws of development of a scientific outlook only in the context of the historical process, taking into consideration the stages of advancement of scientific knowledge, and in interrelationship with other sciences and with the social conditions of various historical periods.

Understanding life as a function of a lawful geochemical mechanism in the biosphere, Vernadsky believed that biology, together with physics and astronomy, would provide deep insight into the foundations of the Universe. Remaining faithful to an empirical approach in his study of natural phenomena, yet rendering theoretical investigations their due, he rejected the views of Pierre-Simon LaPlace, who had asserted that a single formula could describe "everything that takes place in the natural order." Vernadsky thought there were "no grounds for thinking that, with the further development of science, all phenomena capable of scientific explanation would be subsumed under mathematical formulae or under some expression of numerical correlations." In his writings, Vernadsky preferred to use the term "living matter" rather than "life," seeing the former as part of the Earth and of the Cosmos, whereas he considered the concept of "life" to be incomparably broader, extending to philosophy, folklore, religion, and artistic creativity. Basically, he resolutely counterposed his own scientific conception to commonly held philosophical views or religious beliefs. Vernadsky complained that "philosophical thought has turned out to be powerless to compensate for the spiritual unity connecting humanity" and that philosophy lagged behind "the demands of the natural sciences." At the same time, he cherished the humanist idea of the unity of man and the Universe, and we must therefore include him in the ranks of scientists, writers, and philosophers who are outstanding representatives of Russian cosmism, the most noted being space pioneer Konstantin Tsiolkovsky.

Vernadsky had a thesis that became well-known: "Mankind, taken as a whole, is becoming a powerful geological force. And the question is arising before mankind, before man's thoughts and works, of reconstructing the biosphere in the interests of free-thinking humanity as a unified whole." Two very important circumstances underlie this thesis. The first is the understanding, as we have indicated, that life is a planetary phenomenon and that "living matter encompasses and regulates all, or nearly all, the chemical elements in the biosphere." Secondly, humanity stands as one before nature, and therefore no problems of the biosphere have a narrow, national character. "We must not," Vernadsky wrote, "act with impunity against the principle of the unity of all people as a law of nature." We see in this statement the position of a humanist scientist with a deep sense of responsibility for the fate of our planet and concern about an uncontrolled attitude toward global environmental problems, an issue that has now become particularly acute.

Observing the transformation of mankind's economic activity into a powerful factor in the evolution of the biosphere, Vernadsky was very far from thinking that scientific and technological progress should be halted, or that the advance of civilization should be slowed down, much less terminated; he simply called for the rational management of natural resources. "For the first time," he said, "man's life and his culture encompass the entire upper envelope of the planet—in general, the entire biosphere, the entire domain of the planet connected to life. We are present at and vigorously participating in the creation of a new geological factor in the biosphere, a factor of unprecedented power and universality. … Man has actually comprehended for the first time, that he is an inhabitant of the planet and may—must—think and act with a new perspective, not solely with the perspective of a single individual, family, or clan, or of nations or alliances among them, but with a planetary perspective."

These considerations led Vernadsky to the concept of the noösphere (from the Greek word for reason, noös), as a new phase in the evolution of the biosphere. He provided this term, which had been coined in 1927 by the French scientists Eduard Le Roy and Pierre Teilhard de Chardin, with a much deeper significance, discarding, in particular, the mystical connotation which de Chardin, a fervent Catholic, had given to it. Using this concept, Vernadsky developed his own body of work on the biosphere and the inevitability of its transformation into the noösphere. In this new conception, he attributed paramount significance to scientific thought as a planetary phenomenon. Since the scale of human activity, superimposed on natural processes and foreign to them, continually increases and is becoming equivalent to the scale of natural geological phenomena, the evolutionary appearance of man and the development of scientific thought had to become natural processes, like everything else in the surrounding world. Consequently, man's scientific thought must develop according to the laws of nature, and not in conflict with them, striving towards the transformation of natural conditions in the direction of the maximum satisfaction of the material, energy, and aesthetic needs of mankind.

Understanding that "the face of the planet—the biosphere—is being radically changed chemically by man, both deliberately and, chiefly, unconsciously," Vernadsky called for these changes to be deliberately guided by human thought, for only then would the biosphere be transformed into the noösphere, as is necessary for mankind to flourish. Vernadsky understood that this transformation required that each individual take responsibility, and that the efforts of all peoples be joined to solve global problems, by strengthening political and other ties among nations, expanding the limits of the biosphere and stepping out into space, and discovering new sources of energy. He placed particular emphasis on the creation of conditions favorable to the development of free scientific thought, the rational transformation of nature, the prevention of war, and the elimination of poverty and hunger as the Earth's population increases. Here, he allotted an important role to science, being embraced to an ever greater degree in public life, "for science, in point of fact, is profoundly democratic; in it there is 'neither Jew nor Gentile,' " and its significance in the noösphere will continuously grow. This, his forecast, resounds strongly in our age of tremendous progress in science and technology, specifically, through the great breakthroughs in informatics and space technologies which have tightly connected the whole world through the internet and through efficient jet transportation.

"We are undergoing not a crisis, which perturbs the faint of heart," Vernadsky said, "but the greatest watershed in mankind's scientific thought, such as happens only once in a millennium; we are experiencing scientific achievements, the equal of which many generations of our ancestors never saw. Standing at this watershed, surveying the future that is opening up before us, we should be happy that we were destined to experience this, and to take part in the creation of such a future." This was the stand taken in life by the eminent scientist, thinker, and humanist Vladimir Ivanovich Vernadsky, the 150th anniversary of whose birth is being widely celebrated throughout the world today.

References

The article draws on original works of V.I. Vernadsky, which are cited in the text; the monograph Nauchnaya mysl kak planetnoye yavleniye [Scientific Thought as a Planetary Phenomenon] (Moscow: Nauka, 1991); as well as selected works published in the collection Vladimir Vernadsky. Otkrytiya i sudby [Vladimir Vernadsky. Discoveries and Destinies] (Moscow: Sovremennik, 1993); Nauchnoe i sotsialnoye znacheniye deyatelnosti V.I. Vernadskogo [The Scientific and Social Significance of the Activities of V.I. Vernadsky] (Leningrad: Nauka, 1989); V.I. Vernadsky i sovremennost [V.I. Vernadsky and the Contemporary World] (Moscow: Nauka, 1986).

MORE AVAILABLE ABOUT **VERNADSKY** FROM 21st CENTURY SCIENCE & TECHNOLOGY

On the States of Physical Space
Vladimir I. Vernadsky
In this first English translation of a 1938 article draft, Vernadsky proposes that living matter exists as droplets of a Riemannian space, dispersed within the Euclidean space of the inert matter of the biosphere.
Winter 2007-2008

V.I. Vernadsky and the Contemporary World
Academician Erik Galimov
Spring 2013

The Science of the Biosphere and Astrobiology
Academician M. Ya. Marov
Spring 2013

The Vernadsky Strategy
Colonel Alexander A. Ignatenko
Spring 2013

The Transition from the Biosphere to The Noösphere
Vladimir Vernadsky
Spring-Summer 2012

Evolution of Species and Living Matter
Vladimir Vernadsky
Spring-Summer 2012

On Some Fundamental Problems of Biogeochemistry
Vladimir I. Vernadsky
A 1936 commentary on the ongoing work of the Laboratory of Biogeochemistry of the Academy of Sciences of the USSR.
Winter 2005-2006

ON THE NOËTIC PRINCIPLE

Vernadsky and Dirichlet's Principle
Lyndon H. LaRouche, Jr.
A review prompted by an examination of an English translation of V.I. Vernadsky's paper on biogeochemistry.
Winter 2005-2006

Some Words About the Noösphere
Vladimir I. Vernadsky
Vernadsky's 1943 work develops his conception of the human mind as a geological force.
Spring 2005

On the Fundamental Material-Energetic Difference between Living and Nonliving Natural Bodies in the Biosphere
Vladimir I. Vernadsky
The first complete English translation of a 1938 article by the innovative Russian biogeochemist, who saw the human mind as the highest development of natural processes. Translated by Jonathan Tennenbaum and Rachel Douglas.
Winter 2000-2001

Back print issues (prior to 2006) are available at $10 each (U.S.) and $20 (foreign)
Electronic back issues are $10 each.

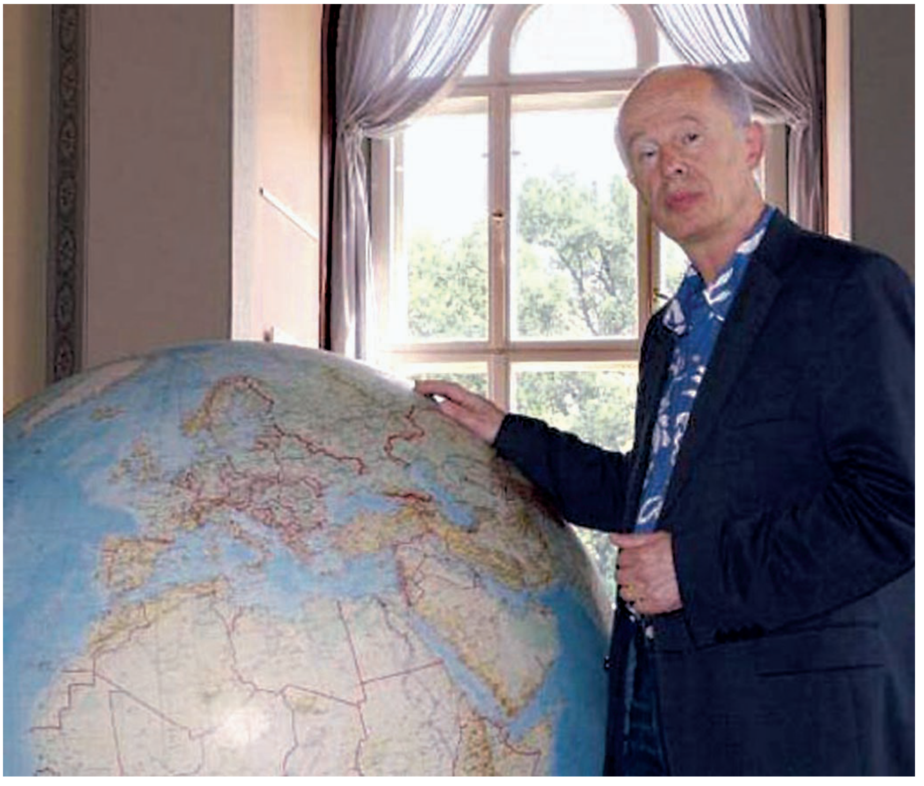
Purchase online at the website store, or send a check or money order to

21st Century P.O. Box 16285, Washington, D.C. 20041

Schellnhuber's Fraud on Vernadsky

by Bruce Director

Falsified data and pre-rigged computer models have become standard fare for the advocates of global warming for whom scientific analysis has only one goal: to prove that mankind's growing influence on the Earth is intrinsically bad and must be curtailed. Some of the more egregious cases, such as the data-faking at East Anglia University, have reached the level of popular international scandal. Yet much more important to understand, is the outright subversion of fundamental scientific discoveries, most notably the attempt by Hans Joachim Schellnhuber, head of the German Advisory Council on Global Change (WBGU) and his cohorts, such as the Dutch nobel-laureate Paul J. Crutzen, to pervert the great Russian biogeochemist Vladimir Vernadsky's concept of the noösphere into the precursor of modern anti-human environmentalism.



nachhaltigkeit2009.commerzbank.de

Hans Joachim Schellnhuber, Commander of the British Empire, promoter of population-reducing policies in the name of defending against "climate change."

Vernadsky coined the term noösphere in 1926 to signify the increasing effect of human creativity as an active power in and over the development of the Earth, the Solar System and beyond, as a reflection of a characteristic of the universe as a whole. On the basis of decades of painstaking research, Vernadsky demonstrated that the evolutionary tendency of the Earth, and more broadly, the universe, was towards higher states of organization and power. This is expressed by the power of living processes to transform non-living matter into new states, and in the uni-directionality of the evolution of life from lower to higher forms, with ever greater power to transform the Earth as a whole. The highest form of this development is the noëtic power of willful creativity unique to only one form of life: the human species. Empowered with creativity, man increasingly dominates the action of life and non-life on the Earth, creating new forms of both. As Vernadsky stated:

> . . . the direction in which the processes of evolution *must* proceed, namely towards increasing conscious-

ness and thought, and forms having greater and greater influences on their surroundings. (emphasis added.)[1]

And:

> Mankind taken as a whole is becoming a mighty geological force. There arises the problem of the *reconstruction of the biosphere in the interests of freely thinking humanity as a single totality.* This new state of the biosphere, which we approach without our noticing, is the *noösphere*.
>
> [M]an becomes a *large-scale geological force*. He can, and must, rebuild the province of his life by his work and his thought, rebuild it radically in comparison with the past.[2]

To recognize, and therefore to become self-conscious of man's role in the universe, Vernadsky argued that science must be able to look at the interaction of the litho-, bio- and noö-spheres as a single process acting on, and being acted upon, by the Solar System, the galaxy, and beyond. For Vernadsky, a promoter of nuclear power, man's role on Earth and in the universe, is to foster, promote, direct, and lead this evolutionary development towards higher states, that can only come about through the power of the human mind's imagination. In sum, Vernadsky is not a friend to modern day environmentalists and greenies like Schellnhuber.

Nevertheless, Schellnhuber (who proudly accepted the title of "Commander of the British Empire" from Queen Elizabeth II) and his collaborators, ludicrously cite Vernadsky's concept of the noösphere, in support of the Empire's desired goal of limiting economic development and population in the name of "sustainability". Were the scientific community and the general public not so corrupted by the myths of environmentalism, such an assertion should have immediately caused Schellnhuber and his ilk to be laughed out of serious consideration. Since that is not the case, we must set the record straight.

Schellnhuber and Crutzen consider themselves firmly in the camp of charlatans who insist that human economic development, especially since 1945, has definitively led to unsustainable stress on the Earth's ability to sustain human life at modern living standards, as expressed, for example, by the dubious parameters often cited as evidence of anthropogenic global climate change. But the reliability of their certitude that continued human progress is leading to disaster, is called into question by Schellnhuber himself. Fancying himself as an expert in non-linear, complex systems analysis, Schellnhuber repeatedly stresses that all attempts at creating mathematical models of such systems are inherently unreliable, as characterized by his call for a second Copernican revolution, in which:

> Scientific ambition is re-qualified by fully acknowledging the limits of cognition as highlighted by the notorious uncertainties associated with nonlinearity, complexity, and irreproducibility; if the Earth system is a clockwork at all, then it is an organismic one that baffles our best anticipatory capacities.[3]

So, on the one hand Schellnhuber cites the failure of mathematical models of non-linear complex systems to argue for limits of human cognition, and on the other hand, he cites the results of such models for the certainty that anthropogenic global climate change is leading mankind to disaster!

It should be no surprise that Schellnhuber, et al. would want to have it both ways, since this Commander of the British Empire is driven by his assigned mission to further the Empire's agenda of population reduction, deindustrialization, and the effective dissolution of the modern nation-state.

This is to be accomplished, according to Schellnhuber and his cronies, under the rubric of maintaining "sustainability" of the "Earth system." It is admitted that "sustainability" can only be vaguely defined as "a normative concept regarding not merely what *is*, but also what *ought to be* the human use of the Earth."[4] The term's vagueness is deliberate, leaving it open as to what *ought to be* and who gets to define it.

On the first account, *what ought to be*, Schellnhuber leaves no doubt as to the direction human development must take. He has repeatedly argued that mankind's economic development has led to global warming and a depletion of natural resources at rates which he designates as unsustainable. He contends that further human development will increase global temperatures and make existing resources either unusable (due to human-caused build-up of toxic substances), or, insufficient (due to his assumption that natural resources are finite and that man's relationship to them is fixed). To have "sustainable" economic development, he argues, mankind must manage

---

1. Vladimir Vernadsky, *The Biosphere*, edited by Mark McMenamin, translated by D.B. Langmuir, 1998.

2. Vladimir Vernadsky, "Some Words About the Noösphere" *21st Century Science & Technology*, Spring 2005, pp. 16-21.

3. Clark, Crutzen, Schellnhuber 2005, "Science for Global Sustainability: Toward a New Paradigm", Harvard University John F. Kennedy School of Government Faculty research working paper; Schellnhuber, 1999, "Earth system" analysis and the second Copernican revolution. *Nature* Vol. 402, supp, 2 December, 1999; Schellnhuber, 2002, "Coping with Earth system complexity and irregularity", in: *Challenges of a Changing Earth*, ed. W. Steffen, J. Jaeger, D.J. Carson and C. Bradshaw, pp. 151–59, Berlin: Springer.

4. Clark, Crutzen, Schellnhuber 2005, op. cit., citing Kates R.W. 2001, "Queries on the human user of the Earth", *Ann. Rev. Energy Environ.* **26**: 1–26.

growth so as to "sustain the life support systems of the planet." While he acknowledges that the earlier concepts of "limits to growth" and "carrying capacity" fail because they assume the Earth system is in a state of thermodynamic equilibrium, a new concept of a "dynamic, causal understanding of how complex nature-society systems respond to stress" must be found.[5] But, he admits that all attempts to produce a mathematical model of such a dynamic have been fruitless, as well they would, since he acknowledges the inherent flaws in the mathematics of complexity. Further, since Schellnhuber insists that human economic development inherently "stresses" the system due to the assumptions just mentioned, he leaves no other conclusion than that sustainable development must ultimately limit population and economic progress. In sum, he assumes a lie, then demands the impossible from it, and obtains from his failure, his intended result.

To paraphrase the saying: it is old wine in new computer models.

On the second matter, *who gets to decide*, Schellnhuber is explicit. The great industrial revolution which freed Mankind from feudalism and has resulted in increases in living standards, population, and the intellectual power of man, has been brought about through the institution of the modern nation-state. However, such progress, according to Schellnhuber has put so much stress on the "Earth system" that dramatic changes in environmental policies must be implemented, regardless of their economic impact. "At the Earth system level, however, the processes must be designed in ways that ensure that the political exigencies of participation do not override the environmental exigencies of the problem addressed."[6] Consequently, what *ought to be* should be determined by some supra-national institution that can override the interests of nation-states whose obligation is to the general welfare. For this, Schellnhuber's WBGU proposes the creation of an "Earth Alliance" that would be a powerful institution capable of enforcing environmental policy decided by an "Earth Commission," to decide what *"ought to be,"* and an "Earth Funding" component to provide the money to implement its diktats.[7] If the establishment of such a global institution is not possible, Schellnhuber's fall-back option is to devolve power to local governments. Either way, the nation-state must go and an imperial system of an eco-sovereign ruling over feudal-like micro-entities must be created.

Schellnhuber admits his sustainable Earth system demands an imperial form of world government:

> Participatory decisionmaking has been promoted as being capable of resolving many global and regional environmental problems. There are many benefits of such participation—not the least of which is securing people's rights in industrialized societies. However, can we presuppose that such inclusive systems automatically, or even usually, achieve outcomes consistent with fostering the long-term sustainability of the Earth system? There are many reasons to believe, in fact, that such processes are inherently ill-equipped to grapple with the complex dynamics that span large spatial and temporal scales. There may be a tension between "rightness of procedure" and "goodness of outcome."
>
> Despite the difficulties, for reasons outlined below, it is important to support participatory decisionmaking whenever possible—without supposing that such processes would usually be democratic in the strictest sense of the word. . . . Final decisions that weigh scientific, economic, political, social, and cultural considerations are ultimately in the hands of legitimately recognized representatives or leaders—when they exist. Many countries, unfortunately, lack such legitimate leadership.[8]

A supra-national agency with a stable of "scientists" motivated by a virtual cult-like adherence to an imperial doctrine, with the financial resources to determine policy on its behalf, is precisely the feudal structure that produced the collapse of Europe in the 14th century, and from which mankind freed itself beginning with the 15th-century Renaissance. No wonder the Queen of England awarded Schellnhuber the title of Commander of the British Empire.

And here, Schellnhuber's scientific perfidy sinks to its lowest. This new world order is necessitated by the emergence of humankind as a global geological force beginning around the turn of the 19th century, and accelerating most dramatically after U.S. President Franklin Roosevelt's 1945 defeat of the British Empire's attempt to create global fascism. He joins with Crutzen in naming this epoch of geological history, the "anthropocene," and he cites its origins in Vernadsky's concept of the noösphere. Still further, Schellnhuber and Crutzen insist that their plan for what amounts to global eco-fascism fulfills "Vernadsky's vision of an intelligently reflective self-guiding noösphere."[9]

> Institutions include the norms, expectations, rules and organizations through which societies figure out what to do and organize themselves to do it. "Sustainability" itself is a norm, and thus part of the emerging institutional structure of Vernadsky's self-reflexive noösphere.[10]

5. Clark, Crutzen, Schellnhuber 2005, op. cit.

6. Schellnhuber, Crutzen, Clark, and Hunt, 2005, "Earth System Analysis for Sustainability", *Environment* Vol 47 No. 8: pp.11–25.

7. Ibid.

8. Ibid.

9. Clark, Crutzen, Schellnhuber 2005, op. cit.

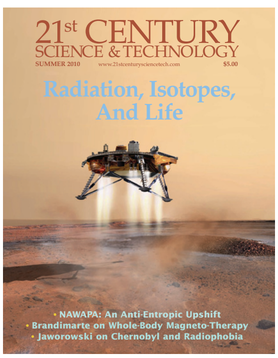
10. Ibid.

The nub of the matter is very straightforward, and has been stated repeatedly by Lyndon LaRouche. The development of mankind throughout history is due to the unique capacity of the human mind to create new ideas that transform both man as a species, and man's relationship to nature. The evidence of human development clearly shows that, as mankind gains greater intellectual mastery over himself and nature, through intertwined progress in art and science, he transforms the Earth and, in the more recent period, the Solar System and potentially beyond. This *anti-entropic* development, in which mankind, through human creativity, creates new states of existence, new forms of life, new resources, and new capacities for development is expressed in Vernadsky's notion of the noösphere. Contrary to Schellnhuber et al.'s sophistry, there is no equilibrium state between man and nature (static or dynamic). Mankind sustains itself only by changing nature into states that could never exist except through the action of human creativity, states which, once brought into existence, produce a capacity for still greater development. Thus, rather than force on man and nature an unnatural state of mythical "sustainability," society must foster and promote an increase in the creative powers of man—something that has been most successfully accomplished through the modern form of nation-state as it emerged in the Renaissance.

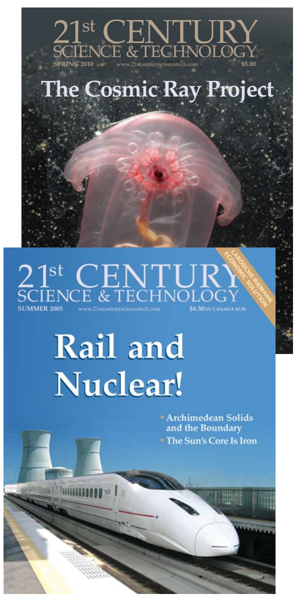
Unfortunately, mankind has, as of yet, not succeeded in fully organizing society self-consciously, consistent with his true nature. While much progress has been made in this regard, especially since the Renaissance, mankind has, nevertheless, been bedeviled by oligarchical imperial systems of "governance" that have suppressed human creativity, and maintain society in a fixed relationship with nature. All such efforts at "sustainability" have failed.

Empires have always employed cult-like beliefs, either in the form of myths, legends, or scientific theories, to dupe their subject populations into accepting the levels of development that the Empire deemed "sustainable." Babylonian cosmology, medieval Arsitotelianism, and the belief in universal increase in entropy are all examples. Schellnhuber et al.'s "sustainability" is no different.

But Vernadsky's concept of the noösphere is. As a committed anti-imperialist, Vernadsky excitedly created new concepts that enabled man to create new resources and higher levels of human development, as his promotion of the development of nuclear energy exemplifies. Consequently, in this year in which we celebrate the 150th anniversary of his birth, we should honor his life and work by defending the true Vernadsky from fakers like Schellnhuber.



Back Issues of
21st CENTURY
SCIENCE & TECHNOLOGY



Are available at
$10 each postpaid
$20 foreign (before 2006)

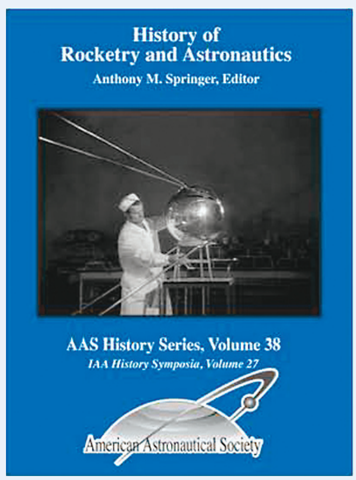
Send check or money order,
U.S. currency only

21st CENTURY
P.O. Box 16285
Washington, D.C. 20041
Or order online at
www.21stcenturysciencetech.com
Index for 1988-2005 available on website

History of
Rocketry and Astronautics

American Astronautical Society History Series

Check out http://www.univelt.com/History.html for a complete listing of these excellent volumes on the history of rocketry and astronautics, including brief descriptions of each volume tables of contents, and ordering information.



Feel free to contact us at:
Univelt, Inc.
PO Box 28130
San Diego, CA 92198

Tel: 760-746-4005
Fax: 760-746-3139

Email: sales@univelt.com

2013 Planetary Defense Conference: Rising to the Challenge

by Benjamin Deniston

For millions of years, asteroid and comet impacts have threatened life on Earth, periodically delivering catastrophic blows to the entire biosphere. Now, however, for the first time in the entire history of Earth, a force exists that could defend the planet from what would otherwise be inevitable future catastrophes. This was the subject of the April, 2013 International Academy of Astronomics Planetary Defense Conference, held in Flagstaff, Arizona.

Bringing together hundreds of scientists from nations all around the world, the conference covered all the main aspects of the challenge. Telescopic systems used to find and track asteroids and comets were discussed, as well as missions to better understand how they can be controlled. And, of course, defense was taken up, with many presentations on various means for altering an asteroid's trajectory, or destroying it if necessary, to ensure it does not impact the Earth.

While a depth of knowledge was demonstrated throughout the five days, it also became clear how much more is needed for a comprehensive defense of Earth.

As some of the participants remarked in various public presentations, planetary defense is nothing less than mankind changing the Solar System: to ensure the defense of Earth, the mind of man must envelop the inner Solar System as a creative force.

Unfortunately, the international strategic frameworks among governments are still far from measuring up to this reality. Although not explicitly discussed, this larger context underlay the conference, even if some participants have become deaf to the signals.

The Chelyabinsk Impact, For Example

Although the program of the Flagstaff conference was set before the asteroid impact, the organizers pulled together a special public session to discuss this remarkable event. Intriguingly, various forms of analysis applied in the attempt to determine the size, speed, energy, and orbit of the asteroid have yielded different results.

Data from seismic stations was used for separate estimations of the energy release by measuring the power of the shock-wave that hit the ground. This indicated 425 kilotons, with a 200-kiloton uncertainty.[1]

Infrasound stations around the world detect sound frequencies far too low for the human ear, but which will

1. One kiloton is a measure of energy equivalent to one thousand tons of TNT.

Table I
Energy Estimations of Chelyabinsk Impact (Kilotons)

Seismic Analysis	Infrasound Analysis	Video Analysis	Government Release
425 ±200	600	415	440

propagate for very large distances. Generally used to detect events like nuclear explosive tests, these stations can also "hear" large meteorite impacts which explode in the atmosphere, such as the Chelyabinsk impact, which generated signals that traveled around the Earth multiple times, lasting for several days. Comparing the readings from different stations, scientists calculated an approximate direction of entry, and the estimated energy released at about 600 kilotons.

In addition, nearly 400 videos of the event were collected and analyzed, to determine the brightness of the explosion, and derive the position and direction of the impact from laborious calibrations and comparisons between different videos and background objects. In video clips that did not capture the meteor itself, but caught the ground lighting up from the explosion, the brightness of the light reflected off car windshields was analyzed as another measure of the size of the explosion. The video analysis indicated an energy level of 415 kilotons.

At some point during six presentations it was casually mentioned that the values being derived from these various methods come close to the values provided by the U.S. military, 440 kilotons. While some people were measuring the light reflected off car windshields as filmed by security cameras, the U.S. government has classified military systems that provide valuable information about the size and nature of small asteroid impacts.

In January of this year, the Air Force Space Command signed a memorandum of understanding with NASA, according to which they agreed to release some information about the meteorite explosions they detect with their systems. Information about the Chelyabinsk event was the first release from this new agreement.[2] While this is seen as a positive step in cooperation between the scientific community and the military, it raises some deeper questions.

Human civilization's continued existence depends upon unleashing the creative powers unique to the human mind, expanding mankind's dominion over the Solar System. While that is fundamentally what it means to be human, it is not the current guiding priority of the institutions which govern human beings.

Detection: Finding Asteroids Before They Find Us[3]

During the conference, it was estimated that there are nine million asteroids about the size of the one that impacted over Chelyabinsk, orbiting in the inner region of the Solar System, of which only some 1000 are known.

The first step in defending the Earth is to find the threatening objects, preferably long before they hit. Since the mid-1990s, NASA has led the way, focusing on finding the largest near-Earth objects (NEOs) first.[4] While the task of finding the largest NEOs has been rather successful (since they are the easiest to see), finding the medium- and small-sized NEOs is more challenging, and there is much work to be done, as indicated in Table II.

During an overview of NASA's activities in detecting NEOs, NASA Headquarters program executive for NASA's Near-Earth Object Program office, Lindley Johnson, said the discovery rate has probably already begun to level off. He explained that the limits are being reached for what can be done with existing technologies, which are predominately ground-based telescopes. To find and track any significant portion of the small and medium-sized NEOs (ones which could destroy an entire city or nation), space-based systems will be needed.

Smaller objects reflect less sunlight, making them harder to see, and searching from the Earth's surface creates additional difficulties. Observations can only be made at night (the half of the sky facing away from the Sun), but from space it is possible to look closer towards the Sun, because there is no atmosphere to deal with. On Earth, weather, such as cloud cover, can pose a problem; not so in space. Many asteroids have orbits that ensure they will not be visible from the Earth for years, but telescopes located in different positions in the Solar System, near Venus for example, would provide a completely new vantage point to view NEO populations otherwise hidden. The Earth's atmosphere blocks certain wavelengths of light from ever reaching the surface, but some of these blocked wavelengths, in the infrared range specifically, can provide a better way to see small, dark objects that reflect little visible light.

If the number of discovered and tracked NEOs is to rise from its present level of around 10,000 to the needed levels of hundreds of thousands and then millions, it will require shifting to space-based systems. A few proposals were presented at the conference.

First, a team led by Amy Mainzer of NASA's Jet Propulsion Laboratory, is proposing a new infrared space telescope to orbit the Earth searching for NEOs. A second mission comes from the non-profit B612 Foundation, which is attempting to raise private donations to send an infrared telescope to a Venus-like orbit for the search effort. Third, the Russian Academy of Sciences is investigating designs for one or two telescopes in Earth orbit, which would search in the visible light range. While none of

---

2. The results are available at http://neo.jpl.nasa.gov/fireballs/

3. To borrow from the title of Don Yeomans' book, *Near-Earth Objects: Finding Them Before They Find Us* (Princeton University Press, 2012). Yeomans is the Supervisor for the Solar System Dynamics Group at JPL and Manager of NASA's Near-Earth Object Program Office.

4. The term "near-Earth object" (NEO) refers to asteroids or comets which have orbits that take them into the inner regions of the Solar System, where they can cross the Earth's orbit and possibly hit the Earth. This term distinguishes them from the larger population of main belt asteroids, orbiting between Mars and Jupiter.

Table II
Asteroid Threat Classes

Size Range (Diameter in Meters)		Range of Impact Effects	Approx. Estimated Population	Approx. Number Found	Approx. Percent-age Found
30 and less	Airburst	Could burn up in the atmosphere unnoticed, or cause structural damage and causalities on a local scale significantly worse than in Chelyabinsk.	12 Million	1,200	~0.01%
30–100	City-killer	Could completely destroy a region from the size of a city to a medium-sized nation.	500 Thousand	2,000	~0.50%
100–300	Nation-killer	Could devastate a region from the size a medium-sized nation to an entire continent. Ocean impacts could cause very wide-spread tsunami devastation.	21,000	2,100	~10%
300–1,000	Continent-killer	A territory ranging from the size of a content to the entire globe.	4,800	2,400	~50%
1,000 and greater	Civilization-threatening	The entire Earth would be affected by the impact effects, including an "impact winter."	900	860	~95%

these three options is currently guaranteed to become operational at this point, any one of them would be a step in the right direction, and all three together would be a larger step, as each alone has its unique inherent benefits, but also specific limitations.

This is what is on the table under the current budgetary and strategic conditions, but are these the fullest capabilities science can provide? How would the detection capabilities change if there were an international strategic agreement between the United States and Russia to apply the fullest capabilities available, and embark upon a serious commitment to develop new technologies to improve mankind's understanding of the structure of the Solar System?

Over the past two years, Russian government officials have proposed cooperation for what they have termed the Strategic Defense of Earth. Unfortunately these offers have apparently fallen on deaf ears in the United States, and there has been no public response.[5]

The issue of reshaping government priorities is posed even more clearly in the subject of stopping a future asteroid impact.

5. Coverage of the repeated offers for a joint U.S.-Russian Strategic Defense of Earth can be found here: http://larouchepac.com/thesde

Defending Earth, and Beyond

Asteroid and comet impacts with the Earth can be stopped, given the right technologies. The key considerations of the challenge are size and time. If the impact can be predicted many decades in advance, the action required could be as simple as slowing the NEO down a tiny amount. Even a small change in speed, if effected many years before Earth impact, can add up to enough of a change in position. The amount of energy needed to generate a particular change in speed then depends upon the size of the NEO in question. On the other hand, if there is less warning time, it may be necessary to destroy the NEO.

While a number of different deflection systems have been theorized and proposed over the years, only a few are considered feasible in the near term. The National Research Council (NRC) published a comprehensive report on planetary defense in 2010, in which they concluded that thermonuclear explosives and "kinetic impacts" (running a spacecraft into the asteroid or comet) are the only options available with existing technologies.[6]

What was not said, either in the NRC report or at the

6. "Defending Planet Earth, Near-Earth Object Surveys and Hazard Mitigation Strategies," by National Research Council's Committee to Review Near-Earth-Object Surveys and Hazard Mitigation Strategies, 2010.

Table III
Planetary Defense Technology is Decades Behind

	Propulsion Systems	Deflection/Destruction Options
Available in 1992	Chemical rockets	Nuclear explosives Kinetic impact
Expected Development by 2012	Nuclear rockets Electric propulsion (solar and nuclear) Mass drivers	Nuclear rockets as thrusters Lasers Hypervelocity penetrations Brilliant darts
Expected Development Beyond 2012	Hypervelocity lunar launch NEO defense in Earth orbit	D-He-3 fusion driver Anti-matter

Source: Workshop Summary, "Assessment of Current and Future Technologies," *Proceedings of the Near-Earth Object Interception Workshop*, Los Alamos National Laboratory, N. M., Jan. 14–16, 1992, pp. 225–34. Febuary, 1993; D. G. Rather, G. J. Canavan, J. C. Solem; Sandia National Labs, Albuquerque, N. M.

In 1992, Edward Teller and other veterans of the SDI project participated in an international workshop at Los Alamos National Laboratory, on defending the Earth from near-Earth objects. One part of that workshop was to assess what general categories of technologies were available at the time, what could be developed within the next two decades (by 2012), and what might be available later. Even though this assessment was a step down from the technological goals of the SDI, the baseline technologies employed today are barely beyond those of 1992, as seen in this table.

Flagstaff conference, is that these are the same fundamental options that were already available in the early 1990s. Although there have been improvements in the technologies associated with these options, there have been no fundamental breakthroughs, despite the fact that the areas where these breakthroughs will occur have been known for decades. (See Table III.)

Kinetic impact and thermonuclear explosives were major focuses of the Flagstaff conference. A series of presentations covered various hypothetical scenarios: large NEOs and small ones, situations with long warning time and those with little. One of the outstanding questions that came up throughout the sessions is the uncertainty in how an NEO will respond to either a kinetic impact or a thermonuclear explosion. Differences in the material composition, density, and structure of NEOs can significantly change how they respond to being hit, and until actual tests are done, there will be no answers.

To shed some light on this matter, the European Space Agency (ESA) and NASA are supporting the kinetic impact test mission Asteroid Impact Deflection Assessment (AIDA). Andrew Cheng of Johns Hopkins University Applied Physics Laboratory presented the mission, which is scheduled for launch in 2019, and impact in 2022. AIDA will include two spacecraft, an impactor (DART), built at Johns Hopkins, and a second spacecraft to monitor the effects of the impact (AIM), built by ESA. DART will crash into the smaller asteroid of a binary asteroid system, 65803 Didymos, and AIM will be able to observe from a safe distance, to determine the efficiency of the impact by measuring the resulting change of the smaller asteroid's orbit around the larger asteroid (an effect that is easier to measure than the change in the orbit of an asteroid around the Sun). Vital information about the response of an asteroid to kinetic impacts will be gained, including crater size, material ejected, seismic effects, shock waves, etc.

A few other kinetic impact tests have been proposed as well. While these presentations elaborated the status and outstanding questions of these current options, there were some more frontier proposals as well. Perhaps most interesting are those involving high-powered lasers.

In the poster session, Philip Lubin, a University of California at Santa Barbara physicist, and Gary Hughes, a Cal Poly San Luis Obispo professor, presented their DE-STAR concept (Directed Energy Solar Targeting of Asteroids and exploRation).* This would be a scalable, modular system, which would convert solar energy into electricity to power an array of lasers. The key to this concept is the "phased array" technology, which allows for the multitude of lasers to be steered and focused to incredible energy densities at the target, vaporizing whatever material it focuses on. The vaporized material then blows off the asteroid, generating a thrust in the process. If the system were built large enough, the thrust would be more powerful than the rocket engines of the

* See interview, this issue.

Space Shuttle, and could be applied for a long period of time.[7]

DE-STAR is the most recent in a short but important list of studies investigating the application of lasers to asteroid deflection. Directed energy systems have many inherent benefits, unmatched by kinetic, explosive, or other proposed systems. Perhaps most important, they can act across space at the speed of light, instead of the days to years it may take for a spacecraft to travel to its target. Once a system is in place, it can be utilized as needed, and each individual application is relatively cheap when compared with designing, building, and launching a new dedicated rocketed space mission.

Such a system could also be multipurpose, with applications for removing space debris from Earth orbit, acquiring better positions and orbit of NEOs, and vaporizing small parts of NEOs to measure their composition and structure for scientific purposes. It may even be possible to use such a system to propel spacecraft throughout the Solar System.

To the Future

Defending the Earth from asteroid and comet impacts challenges all nations in a unique way. There is no region on the globe that is less vulnerable than another. No strategic block is exempt from the threat. It boils down to profound and fundamental questions for society: how the creative power of the human mind measures up against the universe.

With millions of hidden NEOs to discover, the whole sky to watch, and the entire volume of the inner Solar System to ultimately manage, institutions of government are being challenged to organize the potentialities of mankind as a whole, if humanity is to match the realities of living in our Solar System.

This is beyond the scope of any one nation alone. For a truly comprehensive defense, new space capabilities must be developed, new technologies are needed, and a new scientific understanding of the Solar System is ultimately required. Perhaps most important, new levels of strategic cooperation among key nations—specifically the United States, Russia, and China—are needed to focus the efforts of all mankind towards space for a peaceful, cooperative strategic defense of Earth.

Either mankind makes a decision to act in its common interests, for its defense, or mankind faces the threat of extinction, due to its artificial divisions and shortsightedness. Such were the often unspoken realities beneath the surface of the 2013 Planetary Defense Conference.

7. A small to medium-sized asteroid could even be vaporized, if need be.

For More Exclusive Material, See the 21st Century Website

A full conference report, providing a comprehensive overview of the existing and planned planetary defense capabilities of all leading nations involved in the effort, and how these measure up to the realities of the challenge.

Interviews with leading participants:

Boris Shustov – Director of the Institute of Astronomy of the Russian Academy of Sciences, and Head of Russia's Expert Working Group on Asteroids and Comets. Shustov discussed Russia's current efforts to address the asteroid and comet threat.

Dr. David Dearborn – Lawrence Livermore National Lab, Dearborn is an expert on thermonuclear explosives, and their role in planetary defense.

Detlef Koschny – Head of Near-Earth Object segment of ESA's Space Situational Awareness program, Koschny discussed ESA's activity in the three areas of planetary defense, space debris, and space weather.

http://21stcenturysciencetech.com

INTERVIEW: PHILIP M. LUBIN

DE-STAR: Laser Technology For Asteroid Vaporization

What brings you here today for the 2013 Planetary Defense Conference?

I was in Washington for a NASA review, and managed to get out and catch the last two days of the conference. We are here mostly to present an idea for asteroid mitigation. It's some work we've been doing for the last couple of years. It was a good opportunity. I didn't know the conference existed before I started this project. It's a great audience for this kind of work. It's ideal.

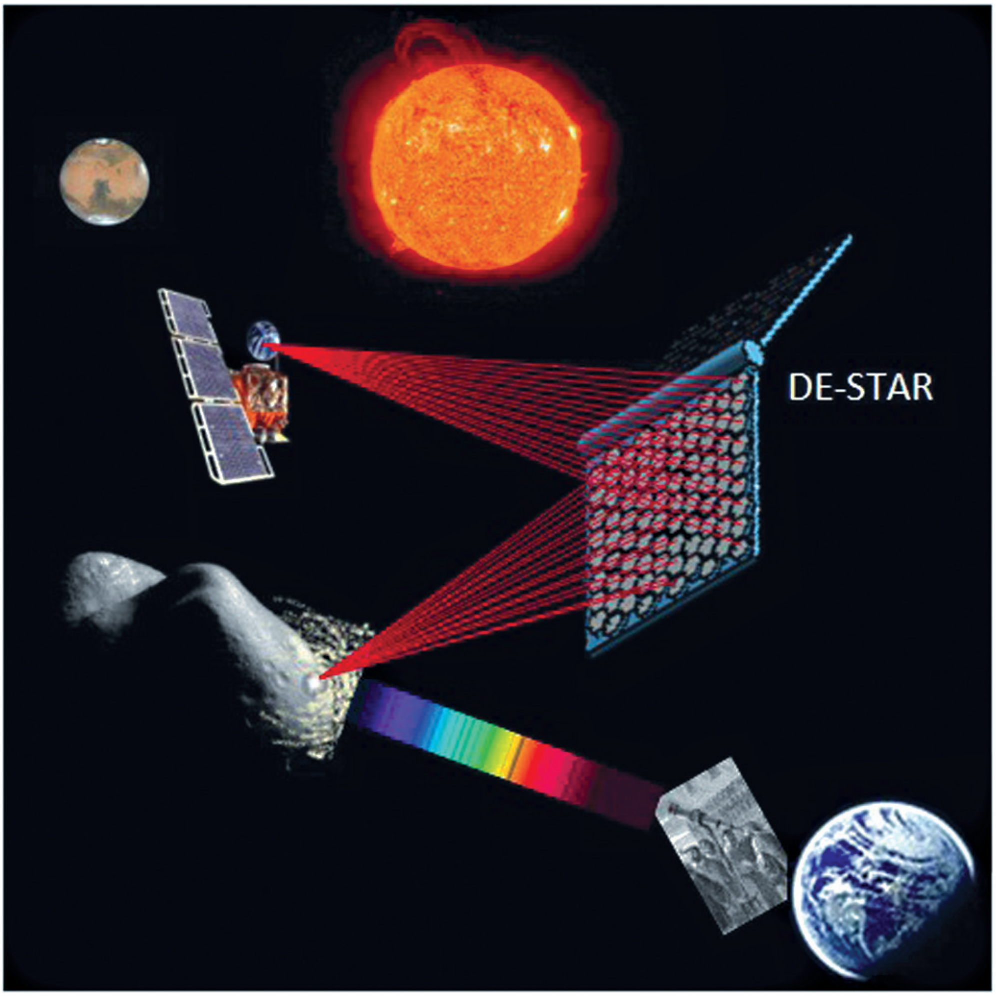
Can you describe your concept? It's called the DE-STAR system, and it's a laser-based system that could be used for asteroid deflection, correct?

It can be used for deflection of asteroids amongst other uses, but it was initially designed to allow us to evaporate asteroids up to 500 meters in diameter completely, in the course of approximately one year. Those were our intellectual marching orders. We said: here's our goal. How can we take some other things we have been doing, and apply it at a much higher level? Is it feasible to do this? So we set as a target 500 meters. We are looking at Apophis as a candidate, which is approximately 300 meters. We set a baseline requirement of approximately 500 meters over a year of complete evaporation, not just deflection, as an absolutely worst-case scenario.

Then we decided that we would like to begin to engage the asteroids and begin the evaporation process at greater than one AU. (One AU is the mean distance between the Earth and the Sun.) So these are very large distances to do something like this. But we set it as a goal to see if it was possible to do this, and that is what evolved into what you see here.

The system is modular, in the sense that you could build small versions of it, not for taking out asteroids, but for testing. So it doesn't require you to build the whole system to validate it, which is one of the other things I wanted to do, to make sure that we didn't have to spend billions of dollars to build something and then find out we made some mistake along the way. So we proposed a system which is very logical and based on a number of existing technologies which are already very compelling. We don't require any technological miracle for this project, which is another requirement that I have. It should be something that's possible to do, even if difficult. And we wanted it to be modular so that we could test it without spending a lot of money, and then work our way up and find out what the problems are, and solve the problems, or find that they are not solvable in the near-term. So far we haven't found any problems that are not solvable. We do see technological challenges, but it does not require any completely new technology at this point. It does require a lot of engineering detail and it does require us to be able to launch and assemble, mostly assemble, large structures in

In this interview, UC Santa Barbara Professor of Physics Philip M. Lubin discusses his DE-STAR (Directed Energy Solar Targeting of Asteroids and exploRation) proposal, a space-based phased-array laser system which could be used to deflect threatening asteroids, remove space debris, analyze asteroid composition, propel spacecraft, and for other purposes. The system would be modular and scalable, offering a larger or smaller square array of lasers for different goals. A smaller DE-STAR 1 or DE-STAR 2 system (measuring 10 or 100 meters) could vaporize or de-orbit pesky space debris in Earth orbit. The proposed 10-km DE-STAR 4 could vaporize an entire asteroid. The large square array of lasers is required in order to tightly focus enough laser energy, and the photovoltaics provide the electrical power. Professor Lubin was interviewed in April, at the 2013 Planetary Defense Conference at Flagstaff, Arizona, by 21st Century Science & Technology *staff writer Benjamin Deniston.*



Courtesy Philip M. Lubin

Artist's conception of the DE-STAR system interrogating an asteroid and propelling a spacecraft.

temperatures at the asteroid of roughly two to three thousands degrees Kelvin, hot enough to vaporize almost all known elements. Some elements we have to get up to four and five thousand degrees Kelvin. That would be if you had a solid carbon asteroid or a solid diamond asteroid, which would be interesting. Nothing that we know of exists like that, but we have the ability to vaporize basically every known element.

So once you do that, once you form a spot which is small enough and intense enough, then you have to ask yourself how you are going to power such a system, and, of course, how much power you need. The answer is that if you want to evaporate asteroids at about one AU or a little bit beyond, you need a system which is about between 1-10km in size. Ten km is six miles, so it is not a small structure. The International Space Station, for reference, is a tenth of a kilometer in size, approximately a hundred meters. This would be one hundred times larger in each dimension, and thus a formidable assembly project in space. Not impossible, but formidable.

The question of power then comes immediately into play because in order to do what we want, we need to be able to provide approximately 70 gigawatts of laser power. At the current efficiency of lasers, which is actually quite good, the type that we are using are already close to 50% efficient, between 35-50%, and there were some reports recently of 69%, so they are already amazingly efficient. So there is not much room left to go on that front with efficiency. There are other areas where we need to improve. But the size of the system that is required to form the small spot also turns out to be just about the right size to be powered by the Sun through converting sunlight into electricity via photovoltaics. So you don't need any other power source on board. You

space. The modularity allows you to send up sub-components that then are assembled into the larger components, so you don't have to send the whole thing up in space at all. You can send up very small things and robotically build it.

So this would be utilizing solar radiation, converting it into electricity and then converting it to a laser-based system which could potentially vaporize either the surface or even the entirety of an asteroid.

In a nutshell, the basic idea is that you want to form a spot on the asteroid and raise the effective temperature of that spot high enough that all known elements will evaporate. The way you do that is you have to have an optical system which is large enough—we'll worry about the phased array part later—to focus a beam at large enough distances so that it is intense enough to begin the evaporation process. That requires surface don't need any reactors. Nothing else, just solar photovoltaics. Those two together give you a system which is capable of powering the lasers and forming the spot on the asteroid.

You can completely evaporate, worst case analysis, completely bring it down to the atomic or molecular level, depending on composition, so that nothing is left of the asteroid except the vapor value which is in space. That is clearly the worst-case analysis. What actually happens along the way, in the process of forming the intense spot, which begins the vaporization process, is similar to boiling a pot of water. The water vapor coming off the pot is actually pushing down on the surface of water. Now you don't notice it because it's a small effect, but in this case, the amount of thrust on the asteroid, from the ejected material coming off the asteroid, which is therefore pushing back on the asteroid, just action and reaction, that thrust is approximately equivalent to the shuttle solid rocket booster (SRB)—*enormous* thrust, so you don't have to vaporize the asteroid completely, you can certainly push it off course dramatically, as compared to any of the other technologies that exist, including using gravity tractors, or attaching small ion engines, which are a few pounds of thrust. This thing puts on the order of a million pounds of thrust on the asteroid, so it's a phenomenal amount of thrust. That is one of the uses.

Actually, when we started, the other thing we wanted in such a system was not only to be able to interdict asteroids, but to able to go out and deflect them or vaporize them as needed, but we want something which would also be useful for other purposes, so that the money spent on it would be returned in other ways.

We looked at spacecraft propulsion, for example. It turns out that the photon pressure on the reflector of the spacecraft is such that you get roughly from here to Mars in approximately three days with a hundred-kilogram-class robotic spacecraft—a small spacecraft, a couple hundred pounds.

So that's basically having this thing in orbit around the Earth and then beaming the power to the spacecraft?

Correct, so it pushes on the spacecraft, and because it pushes on the spacecraft continuously, it's not like a chemical rocket. What normally happens in the mission, say to Mars or to the Moon, is you fire your chemical rocket to get off the Earth. Most of it is gone by the time you get up into orbit. Then if you want to get to the Moon, you fire up, and you fire for a little while. You don't leave it on the whole time. You don't have enough fuel. This system is on, basically, all the time if you want.

Now, there are issues as we discussed earlier. What do you do when you get to Mars in such a system, because it's going at a phenomenal speed. By the time you get to Mars, for a hundred-kilogram-class robotic system, it's going over four thousands kilometers per second: amazing speeds. In fact, it's high enough to exit the galaxy. It's actually higher than the escape velocity of the galaxy. You blow right through the Solar System. Now it takes a while to get out of the Solar System, but you're going at phenomenal speeds compared to any chemical propulsion system that we have envisioned.

So it has applications. I think the whole idea of propelling spacecraft by this technique is something to look at. You have to understand you want to do more than just go past Mars, you want to actually orbit Mars and land. So there are issues that one has to deal with in terms of how to slow down once you get there. Do you carry an ion engine on board that you power from this thing? Because, this is a phenomenal power source. You'd basically have a plug and a long power chord. You just don't have any mass in the power chord that you are dragging around with you. So it has uses. If you think about anything where you want massive amounts if power, this might have some uses for that purpose.

For example, picture the Space Shuttle. How much of the mass of the rocket you see leaving the Earth is actually the Shuttle you want to get out to your location, versus fuel you have to take with you to get off the Earth and then to get to your destination? So, you are saying that we would not have to take that power source with us and be able to provide even more power throughout the whole travel process, correct?

Correct. There are applications where this is appropriate and there are applications where this is not appropriate. One has to carefully analyze where you would use this. But, basically that's correct. If you calculate the amount of power in the Shuttle's solid rocket boosters—those are the two solid rockets on the side—they have approximately 10 to 20 gigawatts of power each. Now we don't normally think about them in terms of power; we think about them in terms of thrust, but if you calculate the power, they are roughly 10-20 gigawatts.

The power of this system, the baseline system, DE-STAR 4, is 70 gigawatts of photon power, so it's not surprising then that one might conclude that the thrust equivalent that you might be able to induce on the asteroid would be comparable to the Shuttle. Now, this does not have an optimal nozzle design on the asteroid. No one designed a nozzle on the asteroid for us, so we lose a factor there in terms of efficiency, but we still have very large thrust on the asteroid. But in terms of propelling a space craft, you don't use the thrust from the ablation of the spacecraft. You could, so that is possible. There is a mode where you use the system to drive an on-board propellant, but not in the sense of a normal propellant as simply being used as a mass you eject.

In that sense it is somewhat akin to an ion engine, except you don't carry the power with you for the ion engine, you send it by this technique. It has vastly higher power per unit area then sunlight, so therefore you don't need to carry a large amount of mass like solar panels with you on the spacecraft. There may be some interesting applications there. We've been looking at some of those.

Another one is to be able to look at the composition of asteroids, by using the start of the evaporation process, which ejects material. In the ejection process you have a very hot surface on the asteroid, so you can see that hot surface through a telescope. So when you have a backlight, and you have material which is being ejected, we have been looking at the possibility of analyzing ejected material. This might be useful for people who want to mine asteroids and want to know what they are made out of. So this might be a stand-off solution for that, to determine the composition. You can also change the trajectory of asteroids, so if you want to harvest them, this allows you to do that in some applications.

What seems so incredible about this, is that you are talking about speed of light action, basically. To go out and figure out what an asteroid is made of, we would currently have to send a whole mission out there, which would take a long time to get there, and it would be very expensive to build the system to get to it. Here you could have a capability already existing, and then from that capability, through speed of light action, you could decipher what that one's made out of, or move that one around. It seems like an incredible capability.

That's correct: this is designed to be a multi-tasking system. It doesn't even have to point in one direction only. It could simultaneously send out multi-directional beams. Because it's a phased array, it could simultaneously send out essentially as many beams as you want, propelling a spacecraft, analyzing the composition of an asteroid, evaporating another asteroid, and sending power to a lunar base. The way the system is built, it can do many things at once.

What you are saying is basically correct. You are not taking with you your power system: you are leaving it at home, and you're sending it at the speed of light. It takes approximately eight minutes to get from Earth to one AU, which is the amount of time it takes sunlight to get to Earth, so eight minutes after you turn the thing on you can begin to intercept an asteroid at 1 AU. Similarly, you can propel a spacecraft by using the light to push on it. You don't have to carry the propulsion system. But again, there are limits of this technology if you want to apply it appropriately, like any technology.

One interesting thing is that we don't require a miracle to get this to go: any anti-matter drives, any warp drives. We don't need even fusion drives, although we hope that those will come someday. Using technologies which both exist now, and are rapidly evolving, we could not only imagine such a system, but actually build small versions of such a system, and then work our way up to the final, larger system.

One last broader question: We are here at the 2013 Planetary Defense Conference, where there have been a lot of discussions on the role of asteroids and comets impacting Earth and affecting life on Earth. There is also growing attention to space weather, such as solar activity potentially affecting life on Earth. It seems that mankind is more and more being confronted with the fact that the Earth is a small part of the whole Solar System, which is a small part of the galaxy. If we're going to continue to progress and exist, we have to be thinking about the Solar System first, then Earth: broader pictures first, then Earth. Do you have any comment on that view that mankind seems to be moving towards?

Yes, I would hope that we could put aside our petty squabbles, and truly deal with things that are meaningful in life. And working together to place ourselves on the Moon as a near-term mission, to have a base on the Moon, is a laudable mission. To do the same with Mars, and then to work our way out, hopefully, to eventually make our way out of the Solar System.

I draw the distinction between things that are realistic to come to fruition, say in a lifetime, versus those things which are perhaps several lifetimes out. One of the things you could ask yourself is, suppose you go further than simply wanting to deal with asteroids or propel spacecraft within our Solar System, what could you do? If you stepped up, and asked, what would happen if you scale this up even larger, could you build a system which could propel a spacecraft to the nearest stars? We spent some of our time in our papers looking at this issue, and you can in theory, and I'm not saying that this is practical at the moment—it's not. But if you follow the same evolutionary approach, and again you don't need new technology here: you need to be able to assemble things in space which are very large. That requires an evolutionary approach to our ability to both launch and assemble in space. So those are areas we need to work on, but if one scales up, you can conclude that if you go to a DE-STAR 6, you can propel a 10,000-kilogram spacecraft, which is basically ten tons, at near the speed of light, so that you could imagine an interstellar probe someday without warp drive or fusion drive.

Now, we have the same problems, what do we do when we get there? How do you slow down, because you are going really fast. But it brings up some fascinating capabilities. I wouldn't advocate sending people there in the beginning. Send out robotic probes, instead. I am very much an advocate of sending out probes into the Solar System and beyond, and we can decide what we want to do with those probes, but I think what you said before is key to one of the differences between this and other approaches. In many other approaches in dealing with asteroids, one sends a mission to an asteroid to deflect the asteroid. One sends a mission to analyze the material. One sends a mission to put an ion engine on the asteroid to change its orbit. In our approach, we don't do that: we stand off and by staying on the Earth or on the Moon or at a Lagrange point, at the different places we can put this, and we say, let's travel with our energy at the speed of light. Let us work on a system that way, rather than having to mount a mission to every asteroid that might be a threat.

In the long run, in the analysis, this is a much cheaper way to do it, because you don't have to launch a mission which, using chemical propulsion systems, could take years to get to an asteroid. And then what do you do when you get there? So this is a different approach altogether.

I appreciate you taking the time to explain this interesting concept for us. Do you have anything else you'd like to add?

I think maybe one way to think about things that are related to what we are doing. If you go to the hardware store and look at an LED light bulb, and ask yourself what went into making this LED light bulb so much better than any incandescent light bulb, and why should I buy this light bulb instead of a compact fluorescent or an incandescent? I agree, that at the moment, the choice between buying an LED and a compact fluorescent is a tough choice, because it is an economic choice. But the economy of that is changing very rapidly. The same technological revolution, the same photonics and electronic revolution, which makes the LED possible in your laser pointer, in the LED light bulb in your flashlight, in the LED light bulb you buy for your home, that same technology is in fact driving what's making this a reality. It is the conversion of electricity to light at high efficiency, and that has now gotten to a point where one can not only *envision* something like this, but one can *build* something like this.

That's very exciting, thank you very much!

You're very welcome!

***EIR* Special Report**

The New Economics | A Science-Driver Program for Recovery

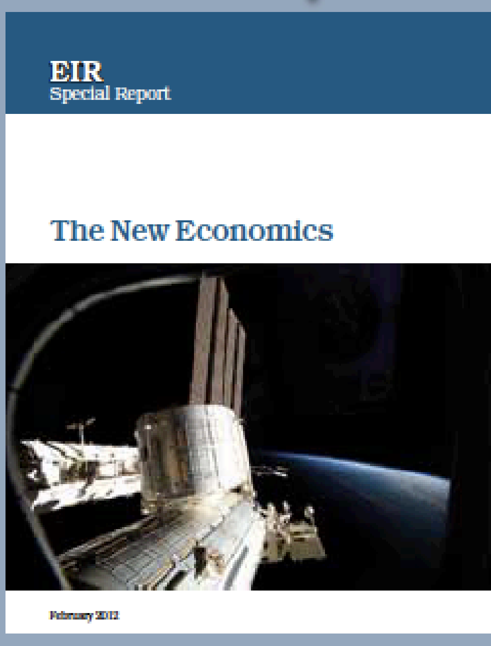
Price: **$100**

(Plus $10 shipping; Va. residents add 5% sales tax)

Includes a 3-month trial subscription to ***EIR Online***

Order from
EIR News Service
1-800-278-3135

Or online:
www.larouchepub.com



This new 80-page report leads with Lyndon LaRouche's **State of the Union address**, followed by:

I. NAWAPA
- Project Overview
- NAWAPA, from the Standpoint of Biospheric Development

II: Arctic Development
- Economics for the Future of Mankind

III: The Moon-Mars Mission
- From the Moon to Mars: The New Economics
- 'The Woman on Mars' (excerpt)

IV: Appendix
- Constitutional Principles for a Recovery
- Franklin Roosevelt's 1933 Glass-Steagall Act
- Alexander Hamilton's Economics Created Our Constitution

Earthquake Update:

The Solar Connection

by Benjamin Deniston

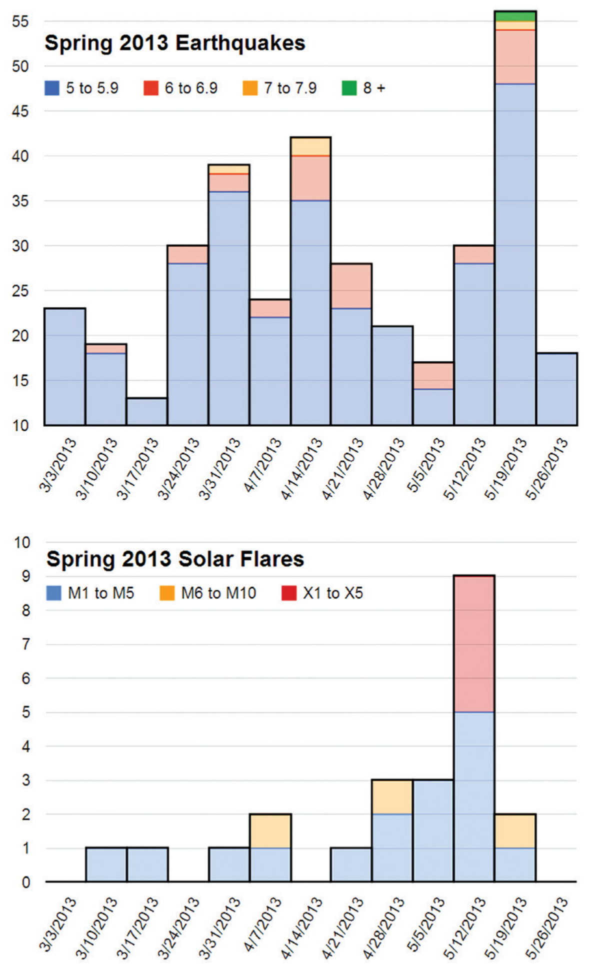
Mid-May featured a period of intense earthquakes and solar activity, bringing some long-standing questions into focus. The largest earthquake in over a year occurred on the morning of Friday, May 24, an 8.3 off the Pacific coast of Russia, in the Sea of Okhotsk. Just over a week earlier, the Sun unleashed two of the largest solar flares of the current solar cycle, an X2.8 on May 13, and an X3.2 the next day. However, these were only the most intense outbursts, which appear to have been part of a broader two-week period of increased Solar System activity, underscoring the need to move beyond simple Earth-based views, and situate processes on Earth within the larger context of our Solar System.

Solar-Earthquake Correlations

As a result of the Sun's flaring up, the Earth experienced two geomagnetic storms, one on May 18 and a second on May 25. A geomagnetic storm occurs when the Earth's magnetic field enters a period of intense fluctuation due to the impact of jets or clouds of plasma unleashed from the Sun.

Interestingly, starting one week prior to the earthquake spike, there was an intense flare-up of solar activity. The Sun released ten large flares between May 12 and May 25, with four of them being the larger X-class flares. These four were the first X-class flares since October 2012, and the X2.8 and X3.2 flares on May 13 and 14 were the largest in over a year, being the third and fourth largest of the entire solar cycle so far (which started in January, 2008). Some of these flares launched high-speed clouds of plasma (called coronal mass ejections) towards the Earth, which can generate disturbances in the Earth's magnetic field, affecting all kinds of Earth systems, biological and otherwise. Over this period two geomagnetic storms shook the electromagnetic systems of the Earth, one on May 18, and a second on May 24, the same day as the large 8.3 earthquake cited above.

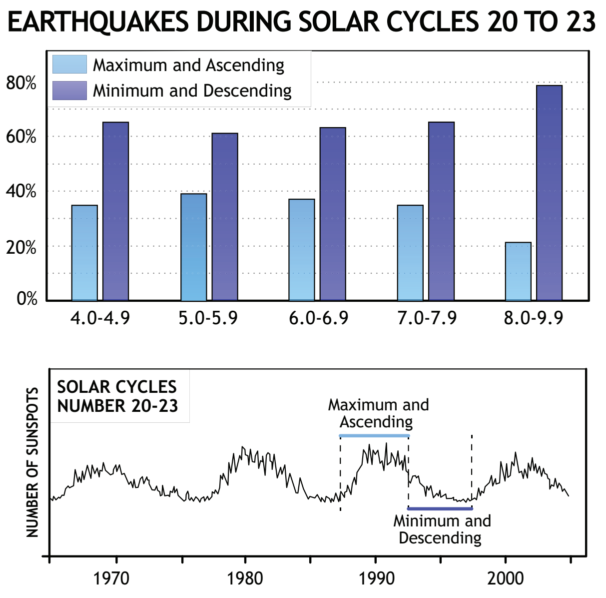
A direct, one-to-one relationship between solar activity and earthquake activity has not been found to exist. However, stepping back and viewing the larger picture, the evidence certainly points to a general relationship. For example, recent studies have shown that the period of the descending half and minimum of the eleven-year solar cycle appears to bring significantly more earthquakes than the ascending half and maximum of the solar cycle. The discrepancy is greatest for large earthquakes.



Top: weekly earthquake totals from early March through the end of May, divided by magnitude range.

Bottom: Weekly solar flare totals. Solar flares are measured by the intensity of the x-ray flux produced, classified on a logarithmic scale as A, B, C, M, or X-class. An X-class flare is ten times more energetic than an M-class, and 100 times more than a C-class.

This is a practical matter, as we are currently rounding the peak of the present solar cycle (number 24), and soon entering the descending phase. What will the next years bring for large earthquakes?



Data from: "Possible Correlation between Solar Activity and Global Seismicity," by J. Huzaimy and K. Yumoto, 2011.

The division of earthquakes occurring in the maximum and ascending half of the solar cycle vs. those occurring in the minimum and descending half.

Earthquake Forecasts

Starting the week before the 8.3 earthquake off the Pacific coast of Russia on May 24, the Russian press was filled with warnings of the possibility of a large earthquake in that region. A series of smaller quakes was catching the attention of local scientists and officials, and although nothing conclusive was declared, some, such as Victor Chebrov (the Director of the Kamchatka branch of the Russian Academy of Science's Geophysical Service) were noting that this could be signs of a larger event to come, as reported by RIA Novosti.

As noted by Chebrov, this activity came in the context of longer-term forecasts for the region. In 2010, Sergei Fedotov and a small team with the Institute of Volcanology and Seismology of the Russian Academy of Sciences, issued a forecast that a large earthquake (magnitude 7.7+) would strike the Kamchatka region some time between September 2011 and August 2016. This was based on a method developed and successfully utilized by Fedotov since the 1960s, analyzing cycles and gaps in seismic activity of a particular region. Alexey Lyubushin, with the Institute of Physics of the Earth, has issued a different long-term forecast for the pacific ocean near Tokyo, Japan. Based on examining patterns in smaller earthquakes, Lyubushin is warning that the next Japan mega-earthquake could occur off the coast of Tokyo in the 2013–2014 period.1

These longer-term forecasts have made the Kamchatka–Japan region a focus for short-term forecasting, using "non-seismic" methods, such as monitoring infrared emissions, irregularities in the ionosphere, earthquake clouds, etc., which can serve as precursor signals, warning of a coming earthquake days or weeks away. For example, the Moscow-based Research Center for Earth Operative Monitoring recently completed a year long short-term forecasting trial program for the Kamchatka–Japan region (eng.ntsomz.ru/projects/earthquake). They were testing a system that could become part of the proposed International Global Monitoring Aerospace Systems (IGMASS) program.2

However, it is not clear that the 8.3 earthquake on May 24th has satisfied the forecast for the Kamchatka region, and as of June 1, some are still warning of an upcoming large earthquake. Yevgeni Rogozhin, the deputy director of the Institute of Physics of the Earth, Russian Academy of Sciences, noted that this was one of the deepest earthquakes ever recorded (over 600 kilometers), and cited the work of Kiyoo Mogi (a leading Japanese authority on earthquake prediction), who has said that very deep earthquakes can be a sign that shallower earthquakes are to follow in the same region. Sergey Pulinets, a Principal Scientific Researcher with the Space Research Institute, Russian Academy of Sciences, told Russian Channel 1 television that the concern for future earthquakes in the Kamchatka region has not been removed, and that generally earthquakes that used to occur once every 100 years are now occurring every 40 years. "The Earth is evolving … the processes are ongoing," said Pulinets.

This is the time to put serious support into non-seismic earthquake forecasting programs, which hold promise for saving countless lives by providing days or weeks of warning time that an earthquake may occur in a given area.3 Unfortunately the development of such systems have been slowed or blocked for political and ideological reasons.

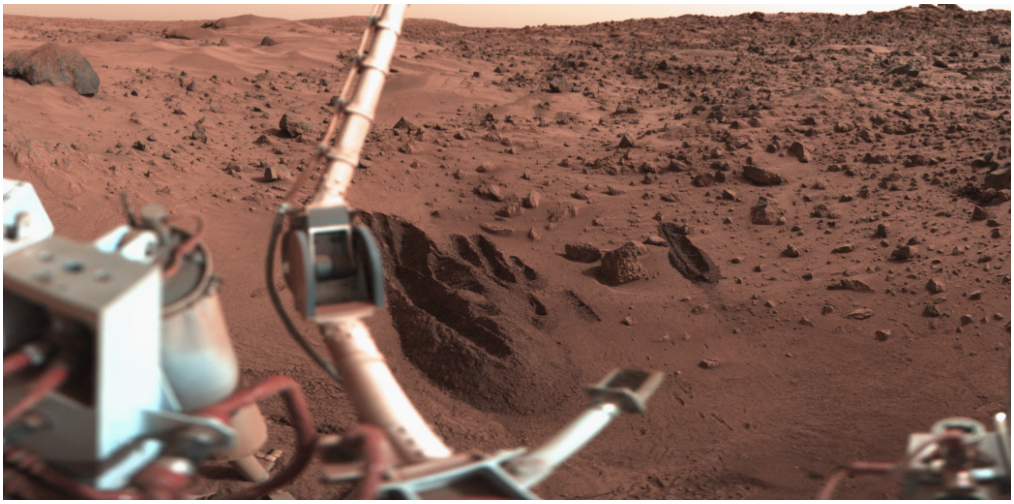
The proposed IGMASS system mentioned above would be an excellent step in international collaboration to develop natural disaster forecasting systems, giving mankind a leg-up on these threats before they strike. For threats we cannot yet stop, forecasting allows us to control our pre-response and the consequences—before we can think about controlling the processes themselves.

---

1. See http://alexeylyubushin.narod.ru/EGU_2013_Extended_Poster_Lyubushin.pdf

2. See the conference report, "International Global Monitoring Aerospace Systems: Toward Collaboration in the Defense of Mankind," by Benjamin Deniston, Pavel Penev, and Jason Ross, in the Fall/Winter 2012-2013 issue of *21st Century Science & Technology*.

3. See the Winter 2011-2012 issue of *21st Century Science & Technology*, "Science Can Predict Earthquakes," and the interview report with Dr. Sergey Pulinets, "A Multi-Parameter Approach to Earthquake Forecasting," http://larouchepac.com/node/17944


NASA

Picture of the Martian surface from the Viking 1 lander.

Practically Missing Mars

by Liona Fan-Chiang

From May 6–8, 2013, scientists, engineers, entrepreneurs, students and onlookers from a variety of different backgrounds gathered at George Washington University in Washington, D.C. at the Humans 2 Mars conference, sponsored by ExploreMars. They were there to present proposals and discuss how to get humans to Mars in the coming decades. What resulted was not a particular road-map which all agreed upon, but both a demonstration of the rich and vibrant history of a United States-led space exploration program, paired with boiling frustration, desperation, and demoralization caused by seeing that program diluted.

Fifty Years of Space

Visionaries such as Krafft Ehricke saw humans integrating the Earth into the rest of the Solar System, exerting increasing dominion over natural processes as we discovered their workings, building infrastructure in low Earth orbit and geosynchronous orbit, industrializing the Moon, building nuclear rockets to get to Mars, conducting science experiments on the Moon and Mars, planting instruments on several planets to see if there are Solar System-wide phenomena such as earthquakes or cosmic ray fluxes, and in general becoming a species which does not inhabit one or two planets, but which thinks of itself as a creative process in the universe, whose mind stretches far beyond its physical reach.

Among the over 25 panels at this conference, several old hands reminded us of what advances these dreams have created.

On an astrobiology panel, associate director of the National Cave and Karst Research Institute, in New Mexico, Penelope Boston, opened by presenting her continuing work on the extremely diverse life found in very distinct caves all over the world, which every day challenge how we define life and the conditions which support it. In order to show just how much we still do not know about life, she concluded with pictures of a mesh structure which has been found in caves all over the world of every rock type, but which is still completely unidentified, pointing out that on Earth we have enough trouble, even with access to microscopic imaging, biological, and chemical techniques, laboratories and scientists from around the world, in characterizing life. Imagine having to compact all of that equipment on to a one-ton Curiosity-sized laboratory!

On the same panel was Gilbert Levin, a scientist with an experiment on the Viking mission, who reminded some, and revealed to many, his original results: that Viking, with its Labelled Release experiment, had in fact found evidence of life on Mars, in 1975. After explaining how the Labelled Release experiment worked, and the many precautions they took to confirm the validity of the results, he posed the obvious paradox:

> the data were extremely compelling, but not accepted. Wouldn't you think that when you get a positive response that confirms a hypothesis, you go back and confirm that response and then expand on that technological beachhead? However, for the 37 years since Viking, no life detection experiment has ever been sent to Mars.

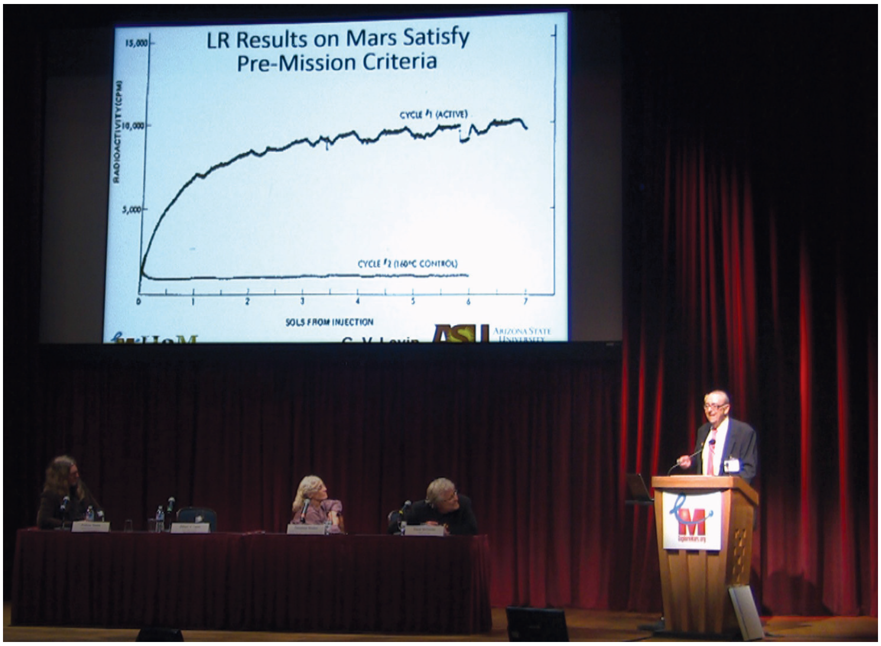
This was followed by an enumeration of the many objections raised about his results:

> The ultimate challenges leveled against us are that there is no liquid water on Mars, no liquid water meaning no life, that Mars is covered with a strong oxidant that destroys organic matter including life, and finally, the instrument on Viking sent to identify organic matter reported zero organics. We showed over the years that that was not so.

In fact, each new mission sent up since Viking has only dispelled many of those criticisms and upheld his results. He concluded by proposing a follow-up experiment, which was actually the original desired experiment for Viking, weight allowing: a chiral release experiment, which would have two separate instruments. Together they could be able to determine whether a preference was given to left-handed amino acids and right-handed carbohydrates, a preference which is characteristic of life on Earth.

> If we got back from Mars that only the left-handed amino acids produced a response, the right-handed one did not, no one would deny that this confirms that we had found life on Viking. If, on the other hand, we get back that only the right-handed amino acids responded, that's amazing, because that tells us we are not related to Martian life. That's a new kind of life. So, this experiment would begin comparative interplanetary biology.

Levin has stood his ground these many years while fierce resistance to taking his results seriously has slowly diminished. Although tension still exists between a now-habitual reference to looking for "conditions for previous life," and Levin's assertion that extant life exists on Mars, his presentation met with fascination rather than skepticism.



21st Century

Gilbert Levin presenting at the Humans 2 Mars conference.

Among others at this conference who have participated in the impressive accomplishments in space over the past two decades, Greg Gentry, who has been working on the International Space Station's Environmental Control and Life Support Systems (ECLSS) since its inception, reviewed a parallel development which has been trekking steadily alongside advances in planetary science: human life support systems on both the International Space Station and the retired Space Shuttles. After quickly showing some of the equipment, and advances which have made supporting human beings in microgravity for increasingly longer durations possible, Gentry highlighted a few of the humbling challenges which have been, and are being, faced along the way. "We had a water separator in our airlock common cabin air assembly that got clogged up because we weren't using our airlock. When we weren't using it we turned it off, which is something the designers never really thought about." Despite much incredible engineering, there will be instances which "the designers never really though about," which is why everything must be tried, not just tested. For example, although they had tested the urine processing system with several urine samples, they hadn't expected, and therefore hadn't designed the system to handle, high calcium content urine. In another situation, they found little washer-shaped zinc oxide particles clogging up a screen. "We don't know where they came from, we don't know how they got formed, or why they were there." Concluding, Gentry warned, "Let us be emboldened by our successes, but hopefully tempered by our mistakes."

Practicality Sets In

This event took place in an environment shaped by a jostled long-term space program and a volatile political and economic climate. Following the cancellation of Constellation, and the plan to return to the Moon and later move on to a manned mission to Mars, the only identified mission announced by the Obama administration has been to send humans to a yet-to-be-identified asteroid.

Keynoting the conference, NASA Administrator Charles Bolden outlined the new plan to identify, capture, relocate, sample and visit an asteroid in the 2020s. This, he said, would be the most reliable, and indeed the only way to get to Mars in the 2030s.

> We think we are on a path that will get us there in the 2030s, but that's a path we've got to follow. If we start straying from that path, going to an alternative plan, where we decide we are going to go back to the Moon and spend a little time developing the technologies and the systems we need, we're doomed. We will not get to Mars in the 2030s, if ever, to be quite honest. Not in your and my lifetime.

Ultimately, he argued, the plan is "affordable, realistic and sustainable." In other words, this is all NASA can afford.

Revealing the conflicts caused by an attempt to adapt to the "practical" situation was the response to a provocative question, during the first panel following Bolden's speech, posed by the former head of the United States Space Nuclear Propulsion Office, Harold Finger, who asked, "why not talk about upgrading what we had developed four decades ago when we said, let's start planning for Mars landings with humans, going with the advanced propulsion based on that technology?" Former astronaut and current head of NASA's Science Mission Directorate, John Grunsfeld, immediately answered:

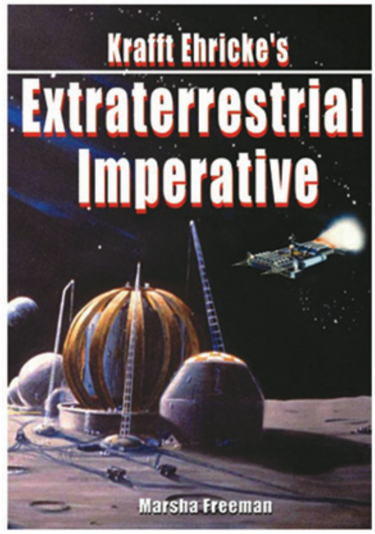
> I agree with you 100%. It's very clear to me that in the long term, if I look out 100 years, or 200 years, if we are really going to go out and explore the Solar System, we need nuclear propulsion of some kind in space to reduce the amount of time to get places with the amount of mass. But I also know, if we are going to have nuclear propulsion, whether fission, fusion, or anti-matter, looking out into the future, that unless you invest in it, it will never happen. I see through our mission directorate, for the first time in a long time, investment into some of those nuclear technologies.

This was, however, followed by NASA Technology Mission Directorate Michael Gazarik, who said, "we have for the past number of decades done a lot of studies and are trying to move beyond that... it takes a considerable amount of money and time to develop and mature it. We don't have the money and the time right now."

Nuclear propulsion came up in smaller discussion several times during the conference. The necessary next step, in order to redefine our relationship to the Solar System, is, and has been, nuclear rockets, along with the associated nuclear research requisite to refine our understanding, and use, of matter. "Of course we need nuclear" is a gut reaction among many. However, several proposals explicitly left out developing nuclear technology because at this point, it is almost a completely new technology, having been abandoned when plans for manned missions to Mars were cancelled, following the success of Apollo.

These included an insane proposal by MarsOne, which perhaps was the quintessential expression of demoralization about changing the current economic, and moral, paradigm, to get around the technology hurdles posed by the return trip from Mars by not facing them at all; that is, by sending astronauts on a one-way trip to Mars! Similarly, at times, an expression of extreme practicality could be heard throughout the conference, even as a qualifier for the validity of a proposal, in the phrase "no new technologies." No new technologies means no new tests, no new development cycles, all of which means less money and less time.

Exploring the Solar System and recreating it as a "garden for mankind" is still the dream. But it will never be fulfilled by being "practical."



Krafft Ehricke's

Extraterrestrial Imperative

by Marsha Freeman

From this new book the reader will gain an insight into one of the most creative minds in the history of space exploration.

Krafft Ehricke's contribution to space exploration encompasses details of new, innovative ideas, but also how to think about the importance and value of space exploration for society.

The reader will gain an understanding of the early history of the space pioneers, what they have helped accomplish, and how Ehricke's vision of where we should be going can shape the future.

At this time, when there are questions about the path of the space program for the next decades, Krafft Ehricke has laid out the philosophical framework for why space exploration must be pursued, through his concept of the "Extraterrestrial Imperative," and the fight that he waged, over many years, for a long-range vision for the program.

Readers will find it a very imaginative work, and a very up-lifting story.

Krafft Ehricke's Extraterrestrial Imperative is the summation of his work on encouraging the exploration and development of space. The book contains all of his reasons why we need to get off the planet and explore space.

ISBN 978-1-894959-91-9

Apogee Books, 2009, 302pp $27.95

www.apogeebooks.com
1-888-557-7223

Obama Tries to Kill Space Exploration, Again

by Marsha Freeman

For each of the past four years, the Obama Administration has proposed a new and innovative way to destroy NASA's capabilities to carry out a long-term and inspiring space program, demoralizing space scientists and engineers, and the American public. The April 10 roll-out of the Administration's proposed FY 14 budget for the space agency was no exception.

Each year, Congress has rebelled, but has only approved holding actions—reversing the most drastic cuts and program cancellations, but not providing enough funding for NASA to be able to actually implement the programs the Congress itself has mandated. As NASA's capabilities decline, and demoralization opens the way for clinically insane proposals, such as one-way human trips to Mars, the nation is losing its distinctly American optimism to create the future.

In previous attempts, the White House has proposed cancellation of the Constellation program for deep-space exploration, decimation of the highly-successful unmanned Mars exploration program, and this year, proposes to send astronauts on a high-risk mission to an asteroid, for no good reason. It really is past time to decide if we want to have a space program, or not.

"It's All We Can Afford"

In 2010, President Obama, upon the self-serving advice of former Apollo astronaut Buzz Aldrin, announced that there was no need to go back to the Moon, because we've "been there; done that." Instead, to find some manned exploration mission which was not the Moon, NASA proposed to send astronauts on a multi-month mission into radiation-soaked deep space in the 2020s, to study an asteroid (which has been, and is being, done already by radiation-hardened robotic spacecraft). This proposal gained no traction on Capitol Hill, within NASA, in the scientific community, or internationally. But this year, the Administration decided it could not even afford such a (senseless) mission to an asteroid, and has come up with a "cheaper" alternative closer to home—the Asteroid Retrieval Mission, to move a near-Earth asteroid into an orbit around the Moon, and then send astronauts there. In May, NASA Administrator Charles Bolden stated directly that given the projected flat NASA budget, the original concept was impractical.

In truth, in the current financial crisis, even this "cheaper" version of a manned asteroid mission is something NASA cannot afford. At a June 18 forum, NASA officials stressed that they were counting on the American "public," companies, universities, international partners, and anyone with a telescope, to identify candidate asteroids, and design systems to capture and redirect them. "We aren't the only player" in space exploration, stated private-space booster, NASA Deputy Administrator, Lori Garver.

This willingness to shrink the national patrimony of decades of science and engineering expertise, and hope "citizens" will fill in the gaps is a stunning abdication of space leadership. As lunar scientist Paul Spudis aptly described it: "we sit amongst the smoldering ruins of a once-great space program." Is "what we can afford" what will define our future in space?

What Is the Mission?

Bill Gerstenmaier, NASA Associate Administrator for Human Exploration and Operations Mission Directorate, presented the fundamentals, and challenges, of the Asteroid Retrieval Mission (ARM) during a series of presentations in mid-April. The Administration's NASA FY14 budget requests more than $100 million to start planning a mission, whose final cost no one can even guess. The three mission segments are: 1) to detect and characterize a candidate asteroid; 2) a robotic rendezvous, capture, and redirection of the target, to a stable retrograde orbit around the Moon; and, 3) a crewed mission to obtain a sample for return to Earth. If it sounds easy, he warned, do not be fooled.

The first step, is to find a 5-7 meter, 500–1,000 metric ton asteroid as a target. Objects this small, many scientists have explained, are difficult to find, especially if of a nonreflective, dark complexion. Finding a right-sized asteroid (anything larger would require more energy to move than this mission allows, and could wreak havoc on Earth, should things not go according to plan) is a significant challenge. Speaking to the NASA Advisory Council, Gerstenmaier said the search could just turn up a discarded upper stage of a Saturn IB rocket, which was mistaken for an asteroid, in 2002.

But finding a target is only the beginning.

The asteroid's spin rate, composition, and trajectory must be appropriate. David Korsmeyer, from NASA Ames Research Center, described the challenge of intercepting a candidate asteroid to the *San Jose Mercury News*, as "a multivariable math game," akin to catching a baseball while on a Ferris wheel.

Gerstenmaier said, in fact, that he is making no promises about actually capturing an asteroid, because not enough will be known about it before the robotic rendezvous craft arrives. The only way to study the object in advance, he said, would be to send a precursor mission. But that would add cost and time, undermining the very rationale of the project!

Once this still-imaginary asteroid is captured, it would be nudged by low-powered thrusters on the robotic spacecraft. Gerstenmaier stressed that it will not be "towed," which would require more propellant, but "redirected." That is, the asteroid must already be on a course toward cislunar space to even make this possible. All told, it is expected to take about one and a half years to reach the asteroid, three years to nudge it into lunar orbit, and another year to move it to the desired, stable orbit. Theoretically, it would be in the right place for a manned visit in 2021. This slow-boat-to-an-asteroid approach is dictated by the use of low-thrust solar-electric propulsion, rather than more capable, high-thrust nuclear systems, which should be prerequsite for such deep space missions.

At the June 18 forum, Lori Garver made her pitch for the mission by reporting on the bipartisan support for planetary defense against asteroids, referencing hearings that have been held in Congress. She also promoted a new Grand Challenge from the Administration, focusing on "on detecting and characterizing asteroids and learning how to deal with potential threats."

Yet, in an April presentation before the Space Transportation Association, Gerstenmaier warned against this argument as a way to garner support for the retrieval mission. Marcia Smith, of SpacePolicyOnline.com reports that Gersenmaier "cautioned that the relationship of this (retrieval) activity and planetary defense... defending Earth from Potentially Hazardous Asteroids (PHAs) that could cause catastrophic damage—is tangential." He said that this mission would increase our knowledge, but may not be "the most efficient and most effective way to get planetary protection." For one, PHAs are much larger than these candidate asteroids, which pose no threat to the Earth. He described selling the program's purpose as planetary protection as "disingenuous." So much for trying to propitiate Congress.

Hands and Feet

On June 19, the space subcommittee of the House Science, Space and Technology Committee released its draft of a two-year 2013 NASA Authorization bill, to replace the three-year 2010 law, which will soon expire. It included no funding for the Asteroid Retrieval Mission. Subcommittee chairman Steve Palazzo (R-MS) said: "Because the mission appears to be a costly and complex distraction, this bill prohibits NASA from doing any work on the project…" The draft reiterates the priorities promulgated in the current Act, in that missions to lunar orbit, the surface of the Moon, and Mars are NASA's human spaceflight long-term goals. The Committee has received support from the space community, voiced by numerous witnesses during a series of hearings over the past three months.

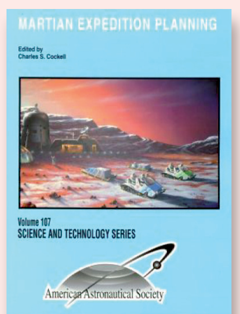
Even Administrator Bolden has had to refrain from proposing the asteroid mission as anything but a retreat in human space exploration. Defending the Administration's budget request before Congress in mid-April, when asked why missions to the Moon had been nixed, Bolden simply said that he would "need money to go to the Moon," saying it would be three times more expensive than this rendezvous with an asteroid.

At a House space subcommittee hearing with Administrator Bolden on April 24, full Committee chairman Lamar Smith (R-TX) advised the witness that, "While federal budgets will continue to be uncertain, Congressional support for NASA's exploration mission is clear and unwavering."

On the same day that the FY14 budget request was sent to Capitol Hill, Representative Bill Posey (R-FL), with bipartisan co-sponsors, reintroduced his Re-Asserting American Leadership in Space Act, to develop a plan for returning Americans to the Moon. However, the bill also calls for keeping within current budgetary constraints.

In order to regain the leadership in space exploration, which is not our birthright but must be earned, Congress will have to stop waving its hands and demonstrate its resolve with its feet.

Books on Mars



These books provide a blueprint for manned missions to Mars and continued presence on the planet's surface, including what technology, precursor missions and experiments are required.

http://www.univelt.com/SciMars.html
Or feel free to contact us at:
Univelt, Inc.
PO Box 28130
San Diego, CA 92198, USA
Tel: 760-746-4005 Fax: 760-746-3139
Email: sales@univelt.com