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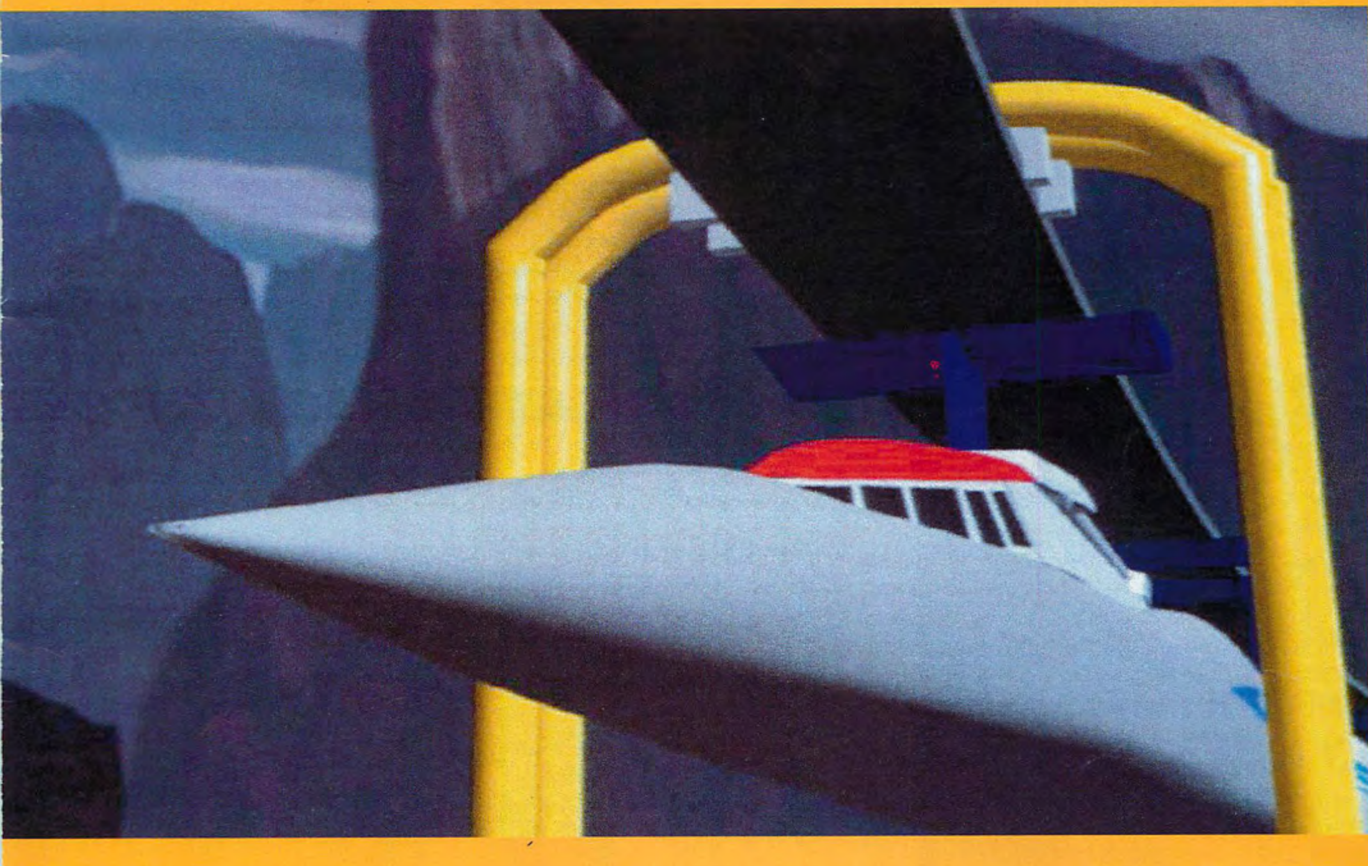

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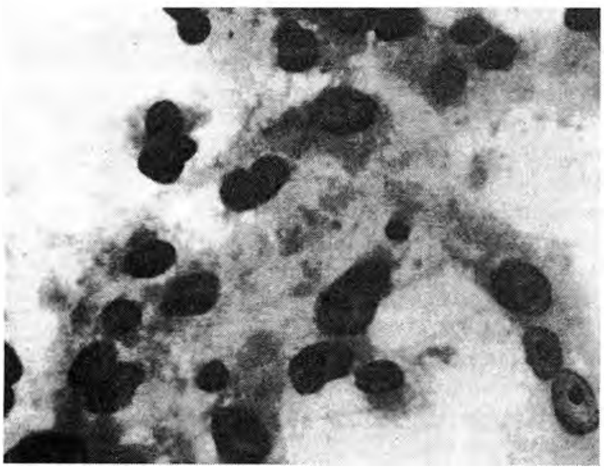
21st CENTURY SCIENCE & TECHNOLOGY

Vol. 13, No. 4 Winter 2000-2001

Features



V.P. Kaznacheyev and L.P. Mihalova, Ultraweak Emissions in Intercellular Interactions (Novosibirsk: Nauka Publishers, 1981)

Mitogenetic radiation: Chick embryo fibroblasts in a sealed chamber, which is connected by a quartz plate to a contaminated chamber for 48 hours, show the same pathology as chick embryo fibroblasts in the contaminated chamber. *See article, p. 60.*

News

Departments

On the cover: Artist's illustration of the Magnetrain on a cross-country route. Photo courtesy of Magnetrain; cover design by Alan Yue.

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Why Dead Minds Can't Know the Noosphere

From ancient times until today, those who have sought to comprehend the organization of our Universe, have generally distinguished among three main *classes* or *domains* of phenomena: First, phenomena occurring in inert or *nonliving* matter, outside of the action of living organisms. Second, *living processes,* that is, the domain of biology. And third, processes connected with the cognitive activity of the *human mind.*

Yet, with the triumph of reductionist thinking in natural science, and above all with the vast development of molecular biology since the middle of the 20th century, the borderline between the living and nonliving has become more and more fuzzy, or even nonexistent, in the minds of scientists.

The Error of Reductionism

The failure to recognize this third alternative—despite Vernadsky's work, and despite the fact, that the essential point involved was familiar long before to Leibniz and even to Plato—reveals an *elementary methodological error,* pervading both modern molecular biology and the attempted approaches of Schrödinger, Prigogine, and others to the physics of living processes.

The nature of the error was clearly identified, more than 500 years ago, by the great Renaissance thinker Nicholas of Cusa, in his critique of Archimedes' work on the *squaring of the circle:* In attempting to approximate a circle by a series of inscribed regular polygons of increasing number of sides, we *appear* to come closer and closer to the circle, but we can never actually *reach* the circle. Even if the number of sides of the polygon were hypothetically to become *infinite,* it would still not resolve to complete *identity* with the circle, because the circle constitutes a higher *species* of geometrical existence. The circle embodies a *higher principle,* namely, that of continuous *rotational action,* which is entirely absent from the linear domain of the polygons. Although the polygons can be constructed from the circle—and in that sense the circle subsumes, as a "higher species," the "lower species" of the polygons—, there is no way to arrive at the circle from the polygons.

Nevertheless, geometers and others expended untold efforts, down through the centuries, in fruitless attempts to *square the circle,* making the same type of mistake as those who, from the time of Pythagoras on, refused to accept the existence of *incommensurable magnitudes* in geometry. The same error emerged later, in the resistance to Leibniz's notion of the infinitesimal calculus, and in the bitter opposition by Kronecker and others to Georg Cantor's introduction of the transfinite numbers.

The attempt of molecular biologists to treat living organisms as "molecular machines" exemplifies the problem perfectly.

There is no doubt that the vast and intricate arrays of biochemical reactions and related processes, identified by modern molecular-biological methods, *do* actually take place in living cells. It *appears* also to be the case, that changes in a living cell, can always be *correlated* in some way with changes in the configurations and motion of molecules. There is thus little doubt, that molecular biology can *approximate* the workings of living processes—perhaps even up to the point of "asymptotic convergence"—in terms of ever more extensive mappings of the purported "molecular machinery" of cells. The latter corresponds, in a methodological sense, to Nicholas of

This editorial is an introduction to the translation of the 1938 paper by Russian biogeochemist Vladimir Vernadsky, on the distinction between living and nonliving bodies in the biosphere, which appears on page 20 of this issue.

Cusa's polygons with increasing numbers of sides.

Now comes the difficulty: None of the molecular-biological approximations, taken by itself, can account for the functional characteristics of living matter in the biosphere, as demonstrated by Vernadsky. We never get, so-to-speak, to the "living part," that is, to the unique characteristic of *action,* which distinguishes living from nonliving processes. That higher characteristic, bears an analogous relation to the domain of "molecular machinery," as rotational action bears to the straight-line action embodied in Nicholas of Cusa's polygons.

To go beyond this, at first glance, purely *negative* observation concerning the limits of reductionist methods, let us go back to the three-fold division of the Universe and have a look at the specific contribution of Vernadsky and of his successor in this matter, Lyndon H. LaRouche, Jr.

Living Matter in the Biosphere

A scientific understanding of the three-fold division of the Universe begins, when we abandon the naive tendency to interpret the basis for the distinctions between the three domains, in terms of the supposedly inherent properties of *objects per se*—for example, living and nonliving objects. What we are really dealing with, as Leibniz emphasized, is distinct *classes of physical principles,* all acting upon the Universe at the *same time,* and which stand in a well-defined hierarchical relationship to each other. That hierarchical relationship is the immediate focus of Vernadsky's life work.

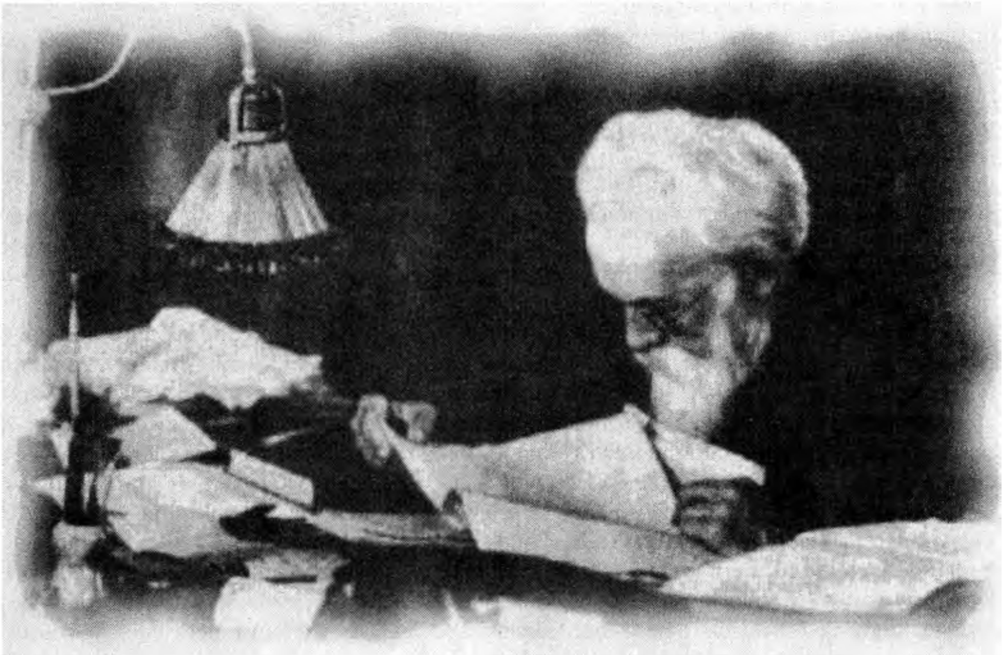
Consider the characteristic *activity* of living matter on the Earth, as exemplified by the case of plants. Living plants grow and maintain themselves by virtue of their ability to absorb water, minerals, and other inorganic materials from the soil, and gaseous molecules from the atmosphere, and to work up this nonliving material into living tissue. Thereby, nonliving matter has been transformed into living matter!

Looking at this on the microscopic level, the question poses itself: What is the nature of the *physical change* which occurs during this transformation? How does an atom of *nitrogen,* for example, which is now part of the plant's living tissue, *differ* from its earlier existence in the mineral fertilizer the farmer put into the ground?

Present-day molecular biologists would characterize the change as merely one of a different chemical *bonding* of the nitrogen atom in the living tissue—for example in a protein or other organic molecule—as compared to the inorganic compound it was part of in the fertilizer. They might hasten to add, that same organic bonding could also be realized in a laboratory just as well, outside of living tissue. Hence, in their view, there is no change on the atomic or molecular level which could be shown to be *unique* to living processes *only.*

Some modern biophysicists, however, would rightly disagree with the simple-minded chemists' conclusions. They will point out, for example that the physical state of an atom depends upon much more than simple chemical bonding; the behavior of atoms and molecules in living tissue is modified by a common quantum-electromagnetic field, which imposes a coupling of processes occurring at distant locations within living tissue. Exactly that feature, is a matter of ongoing, experimental investigation.

Responding in this way, however, both the chemist and the biophysicist would have failed to point out the *most elementary feature* of the process at issue, namely: the *active role* played by the living organism itself, in *imposing,* so-to-speak, a *higher state of organization* upon that nonliving matter. In this way, the organism acts as the *physical cause* of *a continuous and highly directed transformation of its environment.*



Vladimir Ivanovich Vernadsky (1863-1945) at work.

It was Vladimir Vernadsky, who most clearly recognized and demonstrated the nature of that biogenic transformation, by shifting the focus of the investigation from the level of isolated individual organisms, to the aggregate of *all* living matter existing on the Earth at one time, and by studying the *impact* of living matter upon its environment (the biosphere) over the *longest time scale* which is available to precise observation: geological time. Thus, in place of the perilously abstract question "What is life?," Vernadsky substituted a concrete geological question—one concerning the specific role of living matter in the geological history of the Earth.

Vernadsky's main conclusions, based on the analysis of an enormous body of empirical data, can be summarized as follows:

(1) In the course of evolution, the aggregate "free energy" of the living matter in the biosphere—its ability to do work on the environment—has been constantly increasing.

(2) As a result of that increase in free energy, living matter has become the *most powerful geological force* in the biosphere—even though, the total mass of the living organisms themselves, remains a nearly *infinitesimal fraction* of the total, growing mass of matter directly and indirectly affected by their activity within the biosphere.

(3) In the course of evolution, living matter has constantly expanded the "envelope" of the Earth that is populated by living organisms—that is, the biosphere—extending it upward into the atmosphere, into the depths of the oceans, and ever deeper into the Earth's crust.

(4) The capacity for this specific sort of *evolutionary development,* leading to a continual increase in the free energy of living processes in the biosphere, is *unique* to living organisms and is not found in the nonliving domain.

Analysis Situs

But Vernadsky adds a crucial additional conception:

With the emergence of Man and human society, the biosphere has entered a new stage, which Vernadsky called the *Noosphere,* in which *human creative reason* becomes increasingly the dominant, guiding influence in the further expansion and development of the biosphere—including its eventual extension beyond the Earth, into the solar system and beyond.

As regards the question of the Noosphere and the role of human reason, Vernadsky's work remained incomplete. In this respect the direct continuation and completion of what Vernadsky had begun, lies in the work of the American economist and statesman Lyndon LaRouche.[3] Among other things, LaRouche showed:

(1) The absolute distinction between Man and all other forms of life in the biosphere, is empirically demonstrated by the fact, that the human species has been able, through deliberate changes and improvements in the mode of individual and social activity vis-à-vis the biosphere, to increase its overall population-potential by more than a *thousand-fold* in the course of prehistoric and historical development. No other living species has demonstrated that ability.

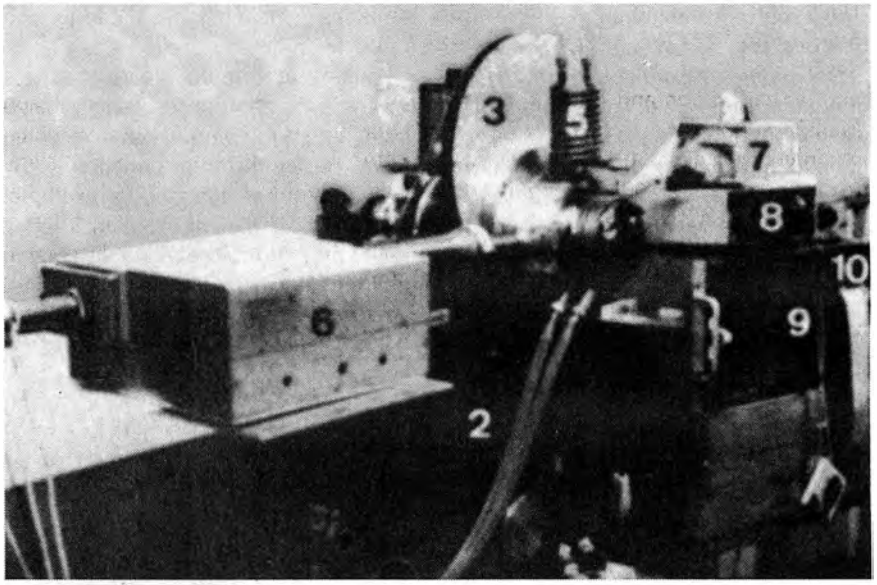
(2) The *cause* of that thousand-fold increase, in the course of history, in the size and quality of the human population that can maintain itself on the Earth, is located solely in the *creative powers of individual human reason* to discover, assimilate, and apply *new scientific principles* and analogous discoveries of principle in art and statecraft, with the effect of improving Man's power to command the forces of Nature (technology).

(3) The action of individual creative reason, upon which the capacity of the human species to effect successive increases in its population potential is based, has a specific and completely *unique* form. It lies in the ability to deliberately seek and discover errors or imperfections in the commonly-accepted assumptions underlying the practice of a society, and to correct or supplement those assumptions, through the discovery and validation of a new universal principle, shown to govern the Universe—and which was either contradicted, or at least not accounted for, by the previously existing assumptions or axioms of thought.

(4) Acts of original *creative discovery* and acts of *creative learning and problem-solving*—of the sort needed to adequately assimilate and apply such discoveries (in the form of new technologies) in the successful practice of society—, are generated *solely* within the "sovereign" mental processes of *individual human beings.* Thus, the process of increase of the population potential of the human species, occurs as a successive integration of specific creative mental acts by individuals, which have the net effect of transforming the overall practice of society. This *unique historical relationship of the individual to the whole* is found *only* in human society, and *only* in connection with human reason; it is entirely lacking in both the other two, lower domains of the Universe.

A Paradox Resolved

What Vernadsky had accomplished for the relationship of *living* to *nonliving processes* in the biosphere, LaRouche has done for the uniqueness of *human reason* relative to *living processes in general.* Thereby, LaRouche brought the questions, *What is human reason?* and



A view of the photomultiplier and focussing device, used in 1976 for detection of ultraweak photon emission from living organisms, as described in Fritz Popp's Biologie des Lichts *(Berlin: Verlag Paul Parey, 1984).*

What is the absolute distinction between Man and all other living species? into the domain of rigorous *empirical-scientific demonstration* and *measurement*—as opposed to what had commonly been regarded as the merely "subjective" realms of religious belief and philosophical speculation.

Combining LaRouche with Vernadsky, we obtain a most lucid and powerful overview of the three-fold division of the Universe.

What we are dealing with, is the differentiation among three, interconnected *classes* or groups of *physical principles* constituting human knowledge of the Universe. For convenience, let us designate them as follows:

A equals physical principles pertaining to nonliving processes generally; *B* equals physical principles pertaining to the unique characteristics of action of living processes, relative to nonliving processes; *C* equals physical principles pertaining to the unique characteristics of human reason.

Note the following paradoxical, but crucial point: Physical principles, insofar as they are valid principles of human knowledge, must be *universal;* they must, at least implicitly, apply to the Universe *as a whole.* The unity and coherence of the Universe (and of human knowledge) would thus seem to demand, that (for example) the principles governing nonliving matter (class *A*) must also apply in some way to living processes; and conversely the principles of living processes (class *B*) must also apply to nonliving processes; and similarly for class *C*. But doesn't this contradict the *absolute, fundamental distinction* between living and nonliving processes, and between living processes and human reason, demonstrated by Vernadsky and LaRouche, and which was the whole point of our discussion so far?

Recalling Vernadsky's demonstration of the *dominion* of living processes over nonliving matter in the biosphere, and LaRouche's related proof for human reason, shows the way out of the paradox.

The principles of living processes are principles for the *action* by which living matter "conquers" and transforms nonliving matter, as the increasingly dominant geological force in the biosphere. Similarly, Man's demonstrated power to deliberately increase his per capita power to command the forces of Nature, through the exercise of human Reason, points to the implicit *universality* of the principles underlying human Reason. Insofar as the Universe "obeys" human Reason,[4] even nonliving matter is implicitly subject to the principles of human Reason, albeit in a different way than the human mind itself. Conversely, living matter, including the brain tissue which is an indispensable substrate for human mental activity, is composed of the same atoms and molecules as nonliving matter; and living matter appears subject to the principles of class *A,* while not being completely determined by them.

What we are therefore dealing with, is a *multiply connected Universe* in the sense of Bernhard Riemann: the principles of classes *A, B, C* are all acting on one and the same Universe, simultaneously and (implicitly) at every location. But at the same time, the three classes of principles stand in a definite *hierarchical* relationship $A < B < C$ to each other, in terms of *physical power* or what Cantor called *Mächtigkeit,* and as evidenced by the growing dominion of living over nonliving matter, and of reason over the living and nonliving domains within the biosphere. Being of different *Mächtigkeit,* the classes *A, B, C* are strictly differentiated from one another; and yet, an overall harmony exists between them, insofar as they jointly define a self-developing, anti-entropic Universe.

This sort of relationship of classes of physical principles, which is well-defined and yet cannot be expressed in logical-deductive terms, is the subject of what Leibniz called *analysis situs.* Vernadsky's work is a brilliant application of that method, to the empirical domain of the naturalist.

Implications for Biophysics

The article by Vernadsky in this issue, exemplifies exactly this use of *analysis situs* as a *method of discovery.* How does the difference between living and nonliving matter, so clearly manifested on the level of the biosphere over geological time-scales, correlate with the physics of living and nonliving processes at *microscopic* scales of space and time? Although the chemical structure of living tissue is totally different from that in matter of inorganic origin, the basic laws of physics and chemistry *appear* to apply to both. No special physical entities, like the "living force" or "living substance" many vitalists believed must exist in living organisms, have ever been found.

Focussing on this paradox, Vernadsky puts forward a bold hypothesis: the peculiar organization of living organisms is a function of a *"different geometrical state of space-time,"* existing inside those organisms, and *different* from the space-time of nonliving processes! Vernadsky suggests, that the space-time of living organisms might be a special type of *Riemannian geometry.* He calls on mathematicians, physicists, and biologists to collaborate on this problem, which, he foresees, could lead to a revolution not only in biology, but in physical science as a whole.

Judging from his discussion of the problem, Vernadsky himself did not have a completely adequate comprehension of Riemann's original geometrical conception. The latter went beyond the idea of a single, fixed geometry (in the sense of the customary non-Euclidean geometry, for example), to embrace the notion of an expanding, *multiply connected manifold* of physical principles or "dimensionalities"[5] as the mathematical *image* of a *self-developing Universe.* Put another way, we must redefine the relationship *A:B,* from the standpoint of the higher relationships expressed by human reason.

Supplementing Vernadsky's argument on the space-time of living processes on this crucial point, we obtain the outlines of an entire program of experimental research. Recent work on "biophoton" interactions of living organisms[6] and related areas of biophysics, is obviously directly relevant to the issue raised by Vernadsky. Placing such work in the broader context indicated here, should help to bring forth its revolutionary implications.

—*Jonathan Tennenbaum*

Notes

1. These three domains seem so utterly different in character, that they have often been treated as disjoint "worlds unto themselves." Into the 18th and early 19th centuries, for example, it was commonly believed by the so-called vitalists and others, that the difference between living and "dead" matter was caused by the presence, in living organisms, of some special "living ener-

gy," "living force" or other physical entity unique to living matter. There were strong doubts, for example, whether the organic chemical substances, generated by living organisms, could even in principle be synthesized in the laboratory, outside living tissue. Meanwhile, for centuries, philosophers occupied themselves with the question, how the *soul* could act upon the *body*—given that mind or soul, and the ideas and thoughts generated by them, appear to be entities of a completely different nature than material bodies.

2. I do not even mention the field of "artificial life," Siamese twin to the equally absurd pseudo-science of "artificial intelligence." The current popularity of both raises the question: Have computers really become intelligent, or have people just become stupid?
3. See, for example, Lyndon H. LaRouche, Jr. "In Defense of Strategy," *21st Century*, Summer 2000, p. 18, and "Where Do We Attach the Head?" *21st Century*, Fall 2000, p. 47.
4. Here I do not mean to imply that Man per se, in an unqualified sense, represents a higher principle commanding the Universe. It is *only* insofar as Man obeys *Reason*, that Man can continually increase his power over the forces of Nature. The unique potential of Man, relative to other living species, lies in his *capacity* for Reason. Whether or not that capacity will be nurtured and developed in each individual, or rather, willfully destroyed, is the central political issue facing the world today.
5. See Note 3.
6. See "Russian Scientists Replicate 'Impossible' Mitogenetic Radiation," this issue, p. 60.

Letters

Greenpeace Denounces Biotechnology as 'Irresponsible'

To the Editor:

Of all the false promises made by the biotechnology industry, the most irresponsible is the suggestion that genetically modified (GM) crops will solve world hunger ("Genetically Engineered Crops Can Feed the World!" by Channaputra Prakash) [Summer 2000, p. 10].

Aid agencies around the world agree that there is more than enough food currently grown to feed everyone. At a recent biotech industry conference in Vancouver, Canada, Dr. Prakash pointed out that 800 million people go to bed hungry every night. This is true. These people go to bed hungry for a number of tragic reasons: some because they cannot afford the food which is grown, others because war, political corruption or the general ineptitude of a distribution system denies them access to food.

There is no biotech fix for these problems. At best, widespread growth of GM crops in developing countries will make food even less affordable; at worst it will destroy the biodiversity of these nations and their ability to feed their hungry populations.

While it is understandable that biotech companies and those working on their behalf are seeking any and all potential markets for their products, let's not confuse their desire to make a profit with some altruistic wish to solve world hunger. To do so is to trivialize a global problem and is, therefore, unforgivable.

Peter Tabuns, Executive Director
Greenpeace Canada

The Author Replies

World hunger and poverty are due to a variety of causes. For the majority who live in rural areas of developing countries and are dependent on farming, low agricultural productivity and subsistence farming are the primary reasons why they are poor and hungry. Scientific solutions to improve crop productivity, where biotechnology can play a catalytic role, will empower the already-marginalized rural sector, by boosting food production, enhancing the income for the small farmer and improving their nutritional security. There is no single credible evidence that bioengineered food are unsafe, or that these crops affect biodiversity. It is ridiculous to say that by increasing the efficiency of food production and cutting down the use of inputs on the farm (with biotechnology) will make food less affordable.

True, there is plenty of food in the world. But, it is insulting and patronizing to propose to a farmer in a developing country, that he seek food aid from the West. What we need is enhanced production of crops in developing countries to boost local economies through technology and trade. The best way to distribute the food to the needy is by empowering them to be more productive and prosperous to produce their own food or to have increased income to buy their food.

An improved knowledge-base can help the developing country farmer to improve the productivity and profitability of the farm by cutting down losses due to diseases, pests, stress, and post-harvest storage. Biotechnology research clearly has shown that this could be done. If an American farmer can profit from growing insect-resistant corn, and cut down the use of pesticides on his farm, why could not a farmer in Kenya or Mexico also benefit from this technology?

It is not just big corporations that are promoting these products, but also many public institutions, such as national agricultural research and CGIAR Centers. Just look at "Golden Rice" enriched with beta-carotene, developed at the Swiss Institute of Federal Research, that can help cut down blindness among millions of children dependent on rice in Asia.

No biotechnology proponent claims to solve "all" the problems causing world hunger, but clearly the massive problem of global food security cannot be addressed without the help of science. It would be irresponsible for Greenpeace and other organizations to deny the developing world—where more than 70 percent of its people are dependent on farming and who spend much of their income on food—access to modern scientific developments because of their anti-development, anti-technology, and anti-corporate ideology.

Does Greenpeace offer any viable alternative solutions to improve food production in the face of increasing population and diminishing land and water resources? The prosperity of the West is not happenstance; it is due to the strategic development of science and technology in a free market environment. Developing countries are just awakening to this wisdom, and many will soon catch up with the West, unless hindered by activists who are interested in keeping the *status quo.*

C.S. Prakash,
Professor of Plant Molecular Genetics
Director, Center for Plant
Biotechnology Research,
Tuskegee University
www.agbiotech.com

The Editor Replies

We find it less than honest that an organization which supports terrorism and genocide (such as by opposition to nuclear energy and the banning of DDT), should label promotion of a useful technology as "irresponsible" and "unforgivable."

Another Solution to the Hanoi Tower Puzzle

To the Editor:

I thought that you might be interested in still another method to generate the number sequence required to solve the Hanoi Tower puzzle ("New Key Unlocks Puzzle of the Hanoi Tower," by Jacob Welsh, *21st Century,* Fall 2000, p. 72). I needed to generate the same sequence in order to unravel multiplexed data samples.

The method uses a simple binary counter. Each time the counter is incremented by one, the bit that changes from 0 to 1 indicates the next number in the required sequence. Since your puzzle has seven wooden blocks, your counter will be composed of seven bits. The generation of the number sequence would then go something like this:

	Bit #							
Count	7	6	5	4	3	2	1	0->1 bit
1	0	0	0	0	0	0	1	1
2	0	0	0	0	0	1	0	2
3	0	0	0	0	0	1	1	1
4	0	0	0	0	1	0	0	3
5	0	0	0	0	1	0	1	1
6	0	0	0	0	1	1	0	2
7	0	0	0	0	1	1	1	1
8	0	0	0	1	0	0	0	4
9	0	0	0	1	0	0	1	1
10	0	0	0	1	0	1	0	2
11	0	0	0	1	0	1	1	1
12	0	0	0	1	1	0	0	3
13	0	0	0	1	1	0	1	1
14	0	0	0	1	1	1	0	2
15	0	0	0	1	1	1	1	1
16	0	0	1	0	0	0	0	5
⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮

By the way, I don't know if it has anything to do with the degeneration of our educational system, but 52 years ago when I was your age [10], I was not wasting my time writing articles for science magazines; I was reading comic books.

Al Bowden
Riverside, R.I.

Proud of TVA Model

To the Editor:

Thank you for the *21st Century* magazine which featured the Three Gorges Dam, along with the TVA.

As a native of the Tennessee Valley, and Chairman of the TVA Board, I am very proud of the fact that TVA's model of integrated river system management has been used throughout history by many developing nations, as you have documented so well.

Our world renowned integrated approach to power production and resource management continues to be an important part of the TVA mission now, and into the 21st century.

Craven Crowell, Chairman
Board of Directors
Tennessee Valley Authority

TVA's Commitment To Work with China

To the Editor:

I greatly appreciated the article, "Three Gorges Dam: The TVA on The Yangtze River," published in the Fall 2000 issue of *21st Century Science & Technology.* I particularly enjoyed the thorough historical accounts from both China's and TVA's perspective.

One additional perspective that I would like to share with you is TVA's commitment in sharing with China how TVA does business. Under the 1980 "Protocol" that you mentioned, TVA committed to an extensive effort, over a three to four year period (1982-1985), to share the TVA model with the Chinese. In addition to the formal seminars, TVA hosted two Chinese engineers to study at TVA (in Knoxville and Chattanooga) under an internship for a full year.

I directed these efforts for TVA. . . .

Daryl R. Armentrout, Manager
Partner and Business Relations
RSO&E
Knoxville, Tennessee

COMING IN
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Science & Technology

- Goethe's Natural Science
- How Brazil's Nuclear Association Defeated Greenpeace
- Barry Fell, Epigrapher: Biography of a Renaissance Man (part 2)

United Nations

DDT house spraying is still the most effective (and least costly) way to combat the spread of malaria. Here, a scene from the Philippines in the 1970s.

'SAVE CHILDREN FROM MALARIA!' CAMPAIGN FIGHTS BAN ON DDT

Malaria is "spiralling" out of control in countries where it once was controlled. The increase is directly related to pressure exerted on developing countries to stop using DDT—pressure that comes from the industrialized world, international aid agencies, the World Wildlife Fund and Greenpeace, Dr. Donald Roberts, a professor of public health at the Uniformed Services University of the Health Sciences, told a Washington press conference Nov. 21. We must bring back DDT, to make it available for house spraying in those areas of the world, mostly the tropics, where malaria is a leading killer, Roberts said. The press conference was sponsored by the Save Children from Malaria! campaign, a coalition of organizations including Africa Fighting Malaria; the U.S.-based Competitive Enterprise Institute; the European Science and Environment Forum of Cambridge, England; the Liberty Institute of New Delhi, and the Institute of Economic Affairs of London. The coalition is campaigning against efforts by the United Nations Environment Program to ban the production and marketing of DDT, under the Persistent Organic Pollutants (POP) convention, now being negotiated.

"Our coalition believes that developing countries shouldn't be pressured to stop using the only chemical they can afford to protect their people," Roberts said. The issue is what value we place on human life. "We need a chemical that will stand guard over people's health." Roberts's research has shown that when house walls are sprayed with DDT, the malaria incidence dramatically declines, even when mosquitoes are resistant to DDT. This is because of the excito-repellency effect—the mosquitoes avoid the presence of DDT even if it doesn't kill them.

RUSSIA OVERCOMES 'CHERNOBYL SYNDROME,' GOVERNMENT SAYS

"The Chernobyl Syndrome has been overcome," the Russian government information website, strana.ru, reported, in announcing the forthcoming startup of a newly completed nuclear power plant in Rostov, on the Don River in the south of Russia. The government policy for a rapid expansion of nuclear power generation is already producing results. The plant, whose final check-out is being personally supervised by Atomic Energy Minister Yevgeni Adamov, was one of a complex of three plants whose construction was halted by the uproar around the April 1986 Chernobyl accident. Now, after exhaustive studies of plant safety, local and national authorities gave the green light to restart construction. Several other Russian plants are now being completed, including two more units in Rostov, as well as reactors in Kalinin and Kursk. Also, in recent interviews, Kurchatov Institute Director Ponomaryov-Stepnoy has been calling for Russia to modernize its nuclear reprocessing technology in order to play a larger role in the "$200 billion world market for nuclear fuel and fuel treatment."

Kiyoshi Yazawa

Scheduled for restart: The Monju Fast Breeder Reactor, under construction in late 1988.

JAPAN TO RESTART ITS DEMONSTRATION FAST BREEDER REACTOR, MONJU

Japan's Atomic Energy Commission decided to restart the experimental Monju fast-breeder reactor as soon as possible, according to a report in the Tokyo newspaper Nikkei, Nov. 24. The reactor was shut down in December 1995 after an accident in which several tons of sodium leaked from its cooling system. The Japanese Science and Technology Agency released a study Nov. 23 saying that Monju and breeder technology were critical to the nation's future. "The reactor 'Monju' will be placed as the core for research and development of Japan's FBR and nuclear fuel cycle, and Japan will aim for [Monju's] restart as soon as possible," the agency said. The science agency noted that nuclear power generation will continue to be Japan's core electricity source as it contributes to the country's self-sufficiency and stable supply of energy.

RSH SYMPOSIUM DISCUSSES BENEFICIAL EFFECTS OF LOW-DOSE RADIATION

From boosting the immune system to putting certain cancers into remission, low-level radiation has documented beneficial effects for human health, reported top-level nuclear and medical researchers, physicians, and others, speaking at a day-long symposium sponsored by Radiation, Science, & Health in Washington, D.C., Nov. 15. Scientists from the United States, Europe, and Japan reviewed the ongoing work in the field, and the need to bring radiation regulations into line with the scientific evidence, doing away with the linear no-threshold concept, which holds that radiation is dangerous at any level.

Marjorie Mazel Hecht

Edward Calabrese, Ph.D. (left), from the University of Massachusetts, spoke about his work as a doctoral student in plant physiology, which (unintentionally) showed the benefits of low-dose radiation, and was not believed, despite repetition of results. Here he talks with RSH head Jim Muckerheide.

AMERICAN NUCLEAR SOCIETY SHOULD TAKE A LESSON FROM BRAZIL

The Brazilian Nuclear Energy Association (ABEN) waged a high-profile aggressive campaign to stop the anti-nuclear lies of Greenpeace in Brazil—and won. Details of the months-long battle, and the coming on-line of Brazil's second nuclear plant, can be found in a news article posted on *21st Century*'s website, www.21stcenturysciencetech.com. A full interview with ABEN director Guilherme Camargo will appear in the next issue. Brazil's victory contrasts sharply with the American Nuclear Society's modus operandi of accommodating to the agenda set by the Malthusian environmentalists.

NATURAL CAUSES FOR TWA-800, SWISSAIR, AND EGYPT AIR CRASHES?

Cornell University astrophysicist Thomas Gold has proposed that the recent crashes of TWA Flight 800 (July 17, 1996), Swissair 111 (Sept. 2, 1998), Egypt Air 990 (October 1999), and the private plane of John F. Kennedy, Jr., may have a common, natural cause: These air crashes occurred along the Northeast American continental shelf, where massive sudden emissions of natural gas, predominantly methane, are known to occur. Gold hypothesizes that the mass of lighter-than-air gas, emitted from the ocean floor, races upward, disabling the aerodynamic stability of the aircraft, and/or causing fires in closed compartments.

Massive, sudden eruptions of gases have occurred in many locations, on land and the ocean floor. They often occur repetitively in the same area, and on land create what is known as "mud volcanoes." Similar eruptions are indicated on sea floors, where large areas are densely covered with circular "pockmarks," of between 10- and 200-meter diameter. All the air crashes were characterized by a situation of extreme urgency, in most cases causing the pilot to override automatic controls, and put the plane into a steep dive, reactions consistent with the hypothesis of a sudden loss of lift, owing to immersion of the craft in a lighter-than-air gas.

Gold, a Professor Emeritus of Cornell University, is best known for his theory that the so-called "fossil" fuels are not the result of decay of organic matter: rather, that they arise from the action of subsurface anaerobic bacteria on methane which percolates upward from deep crustal deposits, formed in early geologic stages of the Earth.

CHINA PLANS PERMANENT MOON RESIDENCE BY 2010

Chinese scientists announced their nation's new spacefaring plans during a series of meetings in October. Luan Enjie, head of the Chinese State Aerospace Bureau, told a forum in Beijing that China will "conduct exploration of the Moon, and actively join international activities for Mars exploration."

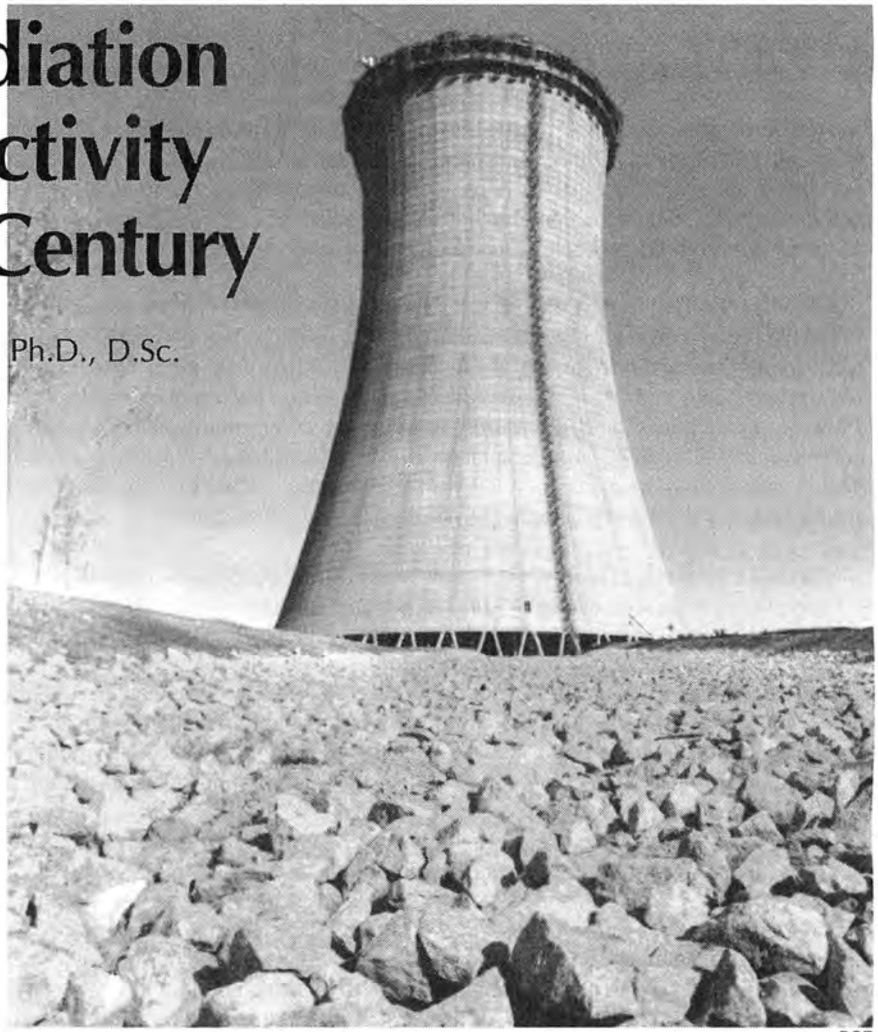
Ouyang Ziyuan, of the Chinese Academy of Sciences, discussed a vision for lunar development over the next two decades. By 2005, he said, the Moon will be home to airtight "cabins," power stations, and other facilities, to be followed by permanent residents in 2010. By 2015, people will build a minibase, and in 2020, a "Moon city," for all human beings.

Officials from China's space robotic center outlined China's plans to send robots to the Moon, based on "breakthroughs [that] have been made in many key technologies of space robots." "Small and dextrous" robots, which are self-repairing, will scour the surface of the Moon, as an advance team for human explorers, said Sun Zengqi, of the computer science and technology department at Beijing's Tsinghua University.

China has not yet announced the date of the second launch of its unmanned spacecraft, Shenzhou. Here, China's LM-3B launch vehicle, largest in the Long March series.

Ionizing Radiation And Radioactivity In the 20th Century

by Zbigniew Jaworowski, M.D., Ph.D., D.Sc.


DOE

A nuclear cooling tower—a symbol of Atoms for Peace. Here, Savannah River's K Reactor cooling tower, during construction in 1991.

Since ionizing radiation and radioactivity were discovered at the end of the 19th century, their social status has oscillated between enthusiastic acceptance, and rejection. This oscillation was concurrent with recognition of three basic aspects of radiation: its usefulness for medical applications and for technical and scientific aims, its beneficial effects at low levels, and its harmful effects at high levels.

In the first part of the 20th century, acceptance prevailed; in the second, rejection. The change of public mood, which occurred rather abruptly after World War II, did not result from the discovery of some new danger of radiation, but from political and social processes that were not related to real radiation effects (Jaworowski 1999). The most important factor of this change was the apocalyptic specter of nuclear war, and its illegitimate child, the linear no-threshold theory (LNT), which was applied to the effects of low doses of radiation.

The possibility of the use of ionizing radiation for medical diagnostics was first demonstrated by W.K. Roentgen, who, one month after his discovery, published an X-ray photograph of the hand of his wife, in *Nature* magazine in January 1896. In 1902, Pierre Curie, together with two physicians, C. Balthazard and V. Bonchard, discovered that radium rays are efficient in cancer therapy.

The theoretical basis for this therapy was posed in 1906 by J. Bergonie and L. Tribondeau as the result of their experiments with rats. They coined the following law: "X-rays are more effective on cells which have a greater reproductive activity." From this law, they commented, perhaps too optimistically, that it is "easy to understand that roentgen radiation destroys tumors without destroying healthy tissues."

The beneficial, or hormetic, effects of low doses of ionizing radiation were found two years after Roentgen and, independently, A.H. Becquerel, announced the discovery of ionizing radiation. The first such effects in algae were reported by Atkinson in 1898. He noticed an increased growth rate of blue-green algae exposed to X-rays. This particular observation was followed by thousands of publications on hormetic effects, and it was repeated and confirmed 82 years later (Conter, Dupouy, and Planel 1980).

That ionizing radiation can be hazardous to man was first reported in the German *Medical Weekly* (Marcuse 1896). The early students and users of radiation voluntarily, or unknowingly, exposed themselves to high radiation doses. Among the pioneers of radiation and radioactivity, about 100 persons had died by 1922, and 406 had died by 1992, all from afflictions that could be

> **"Radiation protection is not only a matter of science. It is a problem of philosophy, morality and the utmost wisdom."**
> —Lauriston S. Taylor, 1957

Le Radium

Le Radium

Three pioneers of ionizing radiation: (from left) W.K. Roentgen, Pierre Curie, and A.H. Becquerel.

related to radiation. These figures, from 23 countries, include scientists, physicists, medical doctors, nurses, and X-ray technicians.[1]

The first fatal victim of ionizing radiation was a German engineer, F. Clausen, who died in 1900. This experience sounded the alarm, and thus the need for protection against high doses of radiation was realized quite early.

In the 1920s, the concept of "tolerance dose" was introduced, defined as a fraction of a dose that caused reddening of the skin. This fraction corresponded originally to an annual dose (in modern units) of 700 mSv. In 1936, the tolerance dose was reduced to 350 mSv; and in 1941, it was reduced further, to 70 mSv.

This concept of tolerance dose, which was effectively a statement of a threshold dose, served as the basis for radiation protection standards for three decades (Kathren 1996), until, in 1959, the International Commission on Radiological Protection made a new recommendation, based on the linear no-threshold principle (LNT) (ICRP 1959).

The introduction of the LNT principle to radiological protection was stimulated by an undue concern, in the 1950s, for the disastrous genetic effects of man-made ionizing radiation on the human population. At that time, one would often see statements by geneticists in the literature on radiation, similar to this one:

". . . We have reached a stage where human mistakes can have a more disastrous effect than ever before in our history—because such mistakes may drastically change the course of man's biological evolution" (Westergaard 1955).

Subsequent history and, especially, the observations of the progeny of survivors of nuclear attacks on Hiroshima and Nagasaki, demonstrated that this concern was an overreaction, tinged with strong emotions, and evoked by the menace of nuclear war. Such feelings are not the best basis for regulations.

Professor W.V. Mayneord, the late chairman of the ICRP Committee IV, commented on using LNT as the regulatory basis: "I have always felt that the argument that because at higher values of dose an observed effect is proportional to dose, then at very low doses there is necessarily some 'effect' of dose, however small, is nonsense" (Mayneord 1964). Mayneord's worry about the values of ICRP recommendations was, as he put it, "the weakness of the biological and medical foundations coupled with a most impressive numerical facade."

During the past several decades, there has been a tendency to decrease the standards of radiation protection to ever-lower values, which in the 1980s and the 1990s, reached 20 mSv per year for people exposed to radiation because of their occupations, and 1 mSv per year for the general population.

Even lower values have recently been proposed: For example, it is proposed that there be a maximum dose of 0.3 mSv in a year for an individual who receives no direct benefit from a source of radiation (Clarke 1999), and for some instances, that the level be 0.01 mSv per year (Becker 1998). Justification for such low levels is difficult to imagine, as *no one has been identifiably injured by radiation while exposed within standards that are hundreds or thousands of times higher,* set by the ICRP in the 1920s and the 1930s (Taylor 1980; Coursaget and Pellerin 1999).

The life expectancy of the survivors of nuclear attacks on Hiroshima and Nagasaki was found to be *higher* than that of control groups (Kondo 1993), and no adverse genetic effects were found in the progeny of survivors (Schull 1998). There is also ample evidence of beneficial effects of low doses of radiation in people who are occupationally, medically, or naturally exposed to doses much higher than the current radiation protection standards (see, for example, Tubiana 1998).

High Costs, No Benefits

For adherence to regulations based on such low standards, society pays hundreds of billion of dollars, with no detectable benefits. Each human life hypothetically saved by implementing these regulations costs about $2.5 billion (Cohen 1992)! Such spending is morally questionable: first, because the limited resources of the society are spent on preventing an imaginary harm, instead of on real advancement of health, and second, because low radiation doses are beneficial for the body.

In fact, for these two reasons, such expenditures to carry out radiation regulations may actually have an *adverse* effect on the population.

In this presentation, I wish to compare the levels of radioactivity and radiation in various environmental situations, as influenced by natural processes and by human practices. Such a comparison may help put radiation standards in a realistic perspective.

What Is Radioactivity?

When life began some 3.5 billion years ago, the natural level of ionizing radiation at the planet's surface was about three to five times higher than it is now (Karam and Leslie 1996). At that time, the long-lived potassium-40, uranium-238, uranium-235, and thorium-232 had not yet decayed to their current levels.

The content of these radioisotopes in the Earth's crust today is still quite high, and it is responsible for the highest radiation exposure of almost all living beings. One ton of average soil contains about 1.3 × 10^6 Bq of potassium-40, thorium-232, and uranium-238, and their daughters. This corresponds to 2.6 × 10^{15} Bq per cubic kilometer (Table 1).

Decay of these natural radionuclides present in a layer of soil 1-kilometer thick, produces 8,000 calories per square meter annually (Draganic, Draganic, and Adloff 1993).

We can compare the natural, extremely long-lived activity of potassium-40 (halflife = 1.28 × 10^9 years), thorium-232 (halflife = 1.4 × 10^{10} years) and uranium-238 (halflife = 4.47 × 10^9 years) in soil, with the activity of much shorter-lived radioactive wastes from the nuclear power cycle.

In 1997, the total annual production of electricity in nuclear reactors was 254.5 gigawatts (GW) (UNSCEAR, 2000a). With an annual production of wastes from nuclear power reactors of 8.8 × 10^9 Bq per megawatt-electric (MWe) (Saas 1997), the global production of radioactive wastes from this source amounts to 2.2 × 10^{15} Bq per year, with the longest lived plutonium-244 (halflife = 8.26 × 10^7 years). This amount of natural activity is contained in a relatively small block of average soil that is 0.9 km square and 1 km deep. None of the man-made components of these wastes has appreciably higher radiotoxicity (expressed as Sv/Bq) than the natural thorium-232 (IAEA 1996).

No special barriers prevent the natural radionuclides from migration from, say, a depth of 1 km to the surface of the ground. They can be transported by mechanical actions, or move in solution.

Thorium is not susceptible to leaching under most geological conditions, and its principal mode of occurrence is in refractory minerals. Uranium is mobile, and may migrate with ground water to distances of several tens of kilometers or more. Radium is highly mobile in sulfate-free neutral or acidic solutions. The average volcanic injections of alpha emitting polonium-210 into the global atmosphere during non-eruptive activity,

Table 1
AVERAGE ACTIVITY OF NATURAL RADIONUCLIDES COMPARED WITH ACTIVITY OF NUCLEAR WASTE (in Bq)

Radionuclides	K-40	Th-232	U-238	Total
Concentration of parents in 1 g of soil	0.420	0.045	0.033	0.498
Number of radionuclides in chain	1	9	14	24
Content in crust (17.3 × 10^{24} g)	7.3 × 10^{24}	7.8 × 10^{23}	5.7 × 10^{23}	8.6 × 10^{24}
Soil (in 1 ton)	4.2 × 10^5	4.1 × 10^5	4.6 × 10^5	1.3 × 10^6
Soil (in 1 km^3)	8.4 × 10^{14}	8.1 × 10^{14}	9.2 × 10^{14}	2.6 × 10^{15}
Wastes from nuclear power reactors in 1997				2.2 × 10^{15}*
Wastes accumulated until 2000 from the whole civilian nuclear fuel cycle, after 500 years cooling				7.4 × 10^{15}*

Notes

* Estimated by the author

The average activity, measured in bequerels, of whole chains of natural radionuclides in the continental crust and soil, compared with the total activity of wastes from nuclear power. The natural activity from nuclear waste is comparable to that contained in a relatively small block of average soil that is 0.9 km square and 1 km deep. None of the man-made components of nuclear wastes has appreciably higher radiotoxicity (expressed as Sv/Bq) than the natural radioisotope thorium-232.

Source: Jaworowski 1990 and UNSCEAR 2000

Table 2
ANNUAL FLOWS OF RADIONUCLIDE ACTIVITY INTO GLOBAL ATMOSPHERE

Source	Activity (Bq)		Energy (J) [e]	
Natural	Rn-222	3.3 × 10^{19}	Rn-222	3.0 × 10^7
Nuclear weapons: explosions and production[a]	H-3	7.0 × 10^{18}	H-3	2.1 × 10^4
Chernobyl[b]	Cs-137	7.0 × 10^{16}	Cs-137	6.1 × 10^3
Nuclear power[c]	H-3	5.6 × 10^{16}	Rn-222	1.3 × 10^4
Natural: Volcanic activity (non-eruptive)[f]	Po-210	5.1 × 10^{15}	Po-210	4.4 × 10^3
Coal burning[d]	Rn-222	8.5 × 10^{14}	Rn-222	7.6 × 10^2

Notes

(a) Annual average for 1945-1980
(b) Emission during 10 days in 1986
(c) Average for 1981
(d) Average for 1980
(e) Decay energies adapted from Magill 1999
(f) Calculated from data of Berresheim and Jaeschke 1983, and Lambert, Le Cloarec, and Pennisi 1988

Shown here are the most important annual flows of activity of radionuclides and of their radiation energy into the global atmosphere. The activity is measured in bequerels; energy is measured in joules. The flow of radioactivity from natural sources into the global atmosphere is 100 to 100,000 times higher than that from particular man-made sources, and the flow of radiant energy is 1,000 to 100,000 times higher than the flow of radioactivity from man-made sources. On the global scale, man-made emissions of radionuclides, and their impact, are dwarfed by the natural sources.

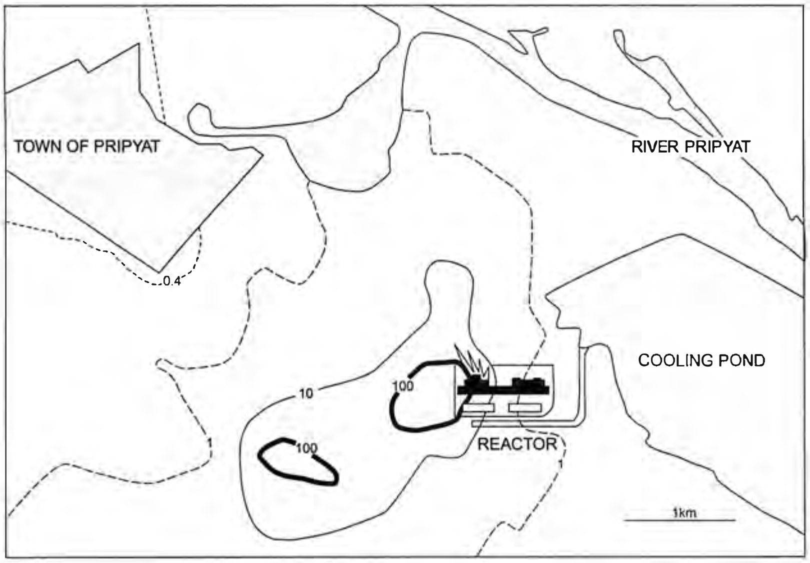


Figure 1
MEASURED RADIATION EXPOSURE RATES IN AIR ON APRIL 26, 1986, IN THE CHERNOBYL AREA

On the first day after the accident, there was a high ground contamination, consisting of two patches in an uninhabited location (heavy lines) with a dose rate of about 1 Gy per hour; this dose rate can be lethal after a few hours. It covered an area of about 0.5 km², and reached a distance of 1.8 km from the burning nuclear reactor.

Several hundred meters outside the 1 Gy isolines, the dose rate dropped by two orders of magnitude.

The units of the isolines are in roentgen per hour.

amount to about 5×10^{15} Bq per year; that is, almost twice as much as the 1997 production of radioactive wastes from nuclear power reactors (Table 2).

Geochemical differences between uranium, thorium, and radium may lead to drastic changes in their radioactive equilibrium (Jaworowski 1990).

In contrast, for man-made radioactive wastes, many effective, sophisticated barriers are provided in deep underground depositories. At a first glance, one can see in Table 1 that it would take about 3 billion years of such a global production of wastes from nuclear power reactors, at the amount produced in 1997, to double the total activity of natural radionuclides in the Earth's continental crust.

The activity of nuclear wastes that have been accumulated up to the end of 2000, from the entire global civilian nuclear fuel cycle. is much greater. It amounts to 200,000 tons of "heavy metals," which, after 10 years of cooling, corresponds to activity of about 7×10^{21} Bq (Semionov and Bell 1993). Disposal of high-level wastes and spent fuel in geologic repositories cannot result in doses to populations until well after 500 years (OECD 2000). After 500 years, the radioactivity of all high level wastes accumulated until now will decrease to about 7.4×10^{15} Bq (Chwaszczewsk, 1999), corresponding to the natural radioactivity contained in an average block of soil, about 1.7 km square and 1 km deep, and consisting of about a 1-billionth part of the natural activity present in the Earth's crust.

It is interesting to compare the annual flows into the global atmosphere of radionuclides from natural sources, with flows from nuclear weapon production and explosions, the nuclear power fuel cycle, coal burning, and the Chernobyl catastrophe. The flows of nine radionuclides, with the greatest potential impact on public health (except for the Chernobyl catastrophe) are compared in Table 2 (Jaworowski 1982). Here, I present only the highest flows of activity from particular sources. To account for various energy emissions by different nuclides, the flows of radiation energy are also given.

Table 2 demonstrates that the flow of radioactivity from natural sources into the global atmosphere is 100 to 100,000 times higher than that from particular man-made sources, and the flow of radiant energy is 1,000 to 100,000 times higher than the flow of radioactivity from man-made sources. It appears that on the global scale, the anthropogenic emissions of radionuclides, and their impact, are dwarfed by the natural sources.

In the case of nuclear power, the highest flow of activity is that of hydrogen-3 (5.6×10^{16} Bq per year), but the highest flow of radiation energy is that of radon-222, because its decay energy (5.6 MeV) is higher by a factor of 300 than the decay energy of hydrogen-3; radon-222 activity flow is only 1.5×10^{16} Bq per year.

This might not necessarily be the case at the local scale, especially in military practices. The widest civilian contamination of ground surface occurred after the Chernobyl accident. On the first day after the accident, which was probably the greatest possible civilian nuclear catastrophe, there was a high ground contamination, consisting of two patches in an uninhabited location with a dose rate of 1 Gy per hour; this dose rate can be lethal after a few hours. It covered an area of about 0.5 km², and reached a distance of 1.8 km from the burning nuclear reactor (UNSCEAR 2000).

Several hundred meters outside the 1 Gy isolines, the dose rate dropped by two orders of magnitude (Figure 1). Fortunately, this situation did not pose immediate danger for the general population. This can be compared with an isoline of 1 Gy per hour after a 10-megaton surface nuclear explosion, reaching (at calm weather) to a distance of 440 km (Miller 1968), and covering with lethal fallout tens of thousands square kilometers.

In the localities remote from the Chernobyl power station, the deposition of radionuclides was much lower, and did not reach levels which could lead to acute radiation health effects, or to chronic effects, such as genetic disturbances, leukemia, or solid cancers (UNSCEAR 2000).

The only exception might be the increase of registration of thyroid cancers in children and adults (UNSCEAR 2000c). Until now only one young girl has been suspected as having died from radiation-related thyroid cancer after the Chernobyl accident (Ilyin 2000; Becker 2000). However, the increase of registration of thyroid cancers may be a result of causes other than Chernobyl radiation, the most probable among them being the screening effect.[2]

Radiation Doses

The global distribution of radionuclides in the biosphere, and the use of radiation are reflected in the radiation doses received by the population from various sources. During the past several decades, the United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR) has been collecting data on doses from radionuclides in the environment, and from their use in medicine and other applications. Although far from being complete, the UNSCEAR compilation of data is the most comprehensive one available, and it enables estimation of the temporal changes in average annual radiation doses received by the global population from particular sources.

In its reports to the General Assembly of the United Nations, UNSCEAR refrained from presenting the results of such estimations expressed in units of rems or sieverts in graphic form. I present them in Figure 2, based on internal documents of UNSCEAR (for a part of medical and natural exposure), and on the UNSCEAR published data (UNSCEAR 1988; UNSCEAR 2000).

The highest annual radiation dose is received from natural sources. The average natural external and internal exposure of the global population currently estimated by UNSCEAR, is 2.4 mSv per year. The natural dose ranges widely in particular regions of the world. UNSCEAR estimates for parts of East Asia and Europe suggest that 39 percent of the population receives annual doses from terrestrial gamma radiation lower than 1.5 mSv; 30 percent receive doses of 1.5 to 1.99 mSv; 18 percent receive doses of 2.0 to 2.99 mSv; 6.3 percent receive doses of 3.0 to 3.99 mSv; and only 0.4 percent receive doses higher than 10 mSv. However, this estimate does not cover areas of high natural radiation background, such as in Iran, India, or Brazil.

For example, in the State of Kerala, India, the annual radiation dose reaches up to 76.4 mGy (a lifetime dose of more than 5 Gy), and it is not associated with an increased cancer incidence or cytogenetic aberrations (Nair et al. 1999). In the area of Araxa, Brazil, which has 74,000 inhabitants, the average annual radiation dose is 24.5 mGy. In the city of Ramsar, Iran the absorbed dose rate in air reaches up to 153 mGy per year (UNSCEAR 2000).

In some parts of Ramsar, people are living in houses where the annual radiation dose is up to about 700 mGy (Mortazavi, 2000). This is comparable to the value of the tolerance dose established in the 1920s, and corresponds to a lifetime dose of about 50 Gy. In the area of Ramsar, people are exposed to such high radiation levels for several generations. Cytogenetic studies have shown differences between these people and control groups, but the Ramsar population shows no increase in the incidence of cancers and leukemia.

Man-made Sources Are Trivial

Compared with the apparently nonharmful annual doses in the high natural radiation areas, the average doses received by the global population from man-made sources seem to be of no importance. This statement is valid also for about 4.8 million people living in areas contaminated by the local fallout from the Chernobyl accident (UNSCEAR 2000), where the average annual radiation dose is about 6 mSv. The highest average dose to the global population from Chernobyl fallout was 0.045 mSv in 1986.

Global exposure from medical diagnostics was rapidly growing from the 1950s, probably the result of steadily increasing access to X-ray technology in the developing countries. However, since the 1980s this exposure seems to have stabilized. Even at its greatest con-

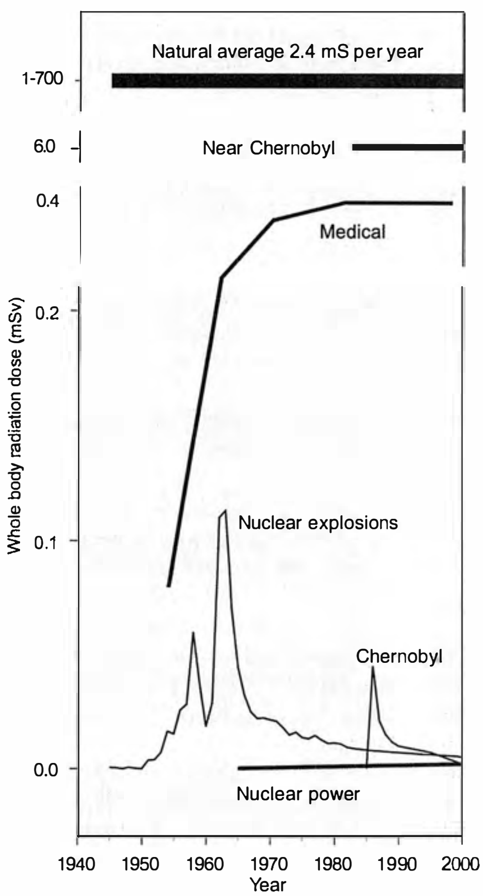


Figure 2
ANNUAL TRENDS IN AVERAGE INDIVIDUAL GLOBAL RADIATION DOSES BY SOURCE (1940-2000)

By far, the highest annual radiation dose is received from natural sources—and has remained constant. The average natural external and internal exposure of the global population currently estimated by UNSCEAR, is 2.4 mSv per year, but doses vary widely across the globe. The natural radiation dose dwarfs that from medical procedures, from nuclear explosions, and from the Chernobyl accident. Radiation from nuclear power plants is near zero.

Source: Based on UNSCEAR 1988, UNSCEAR 2000

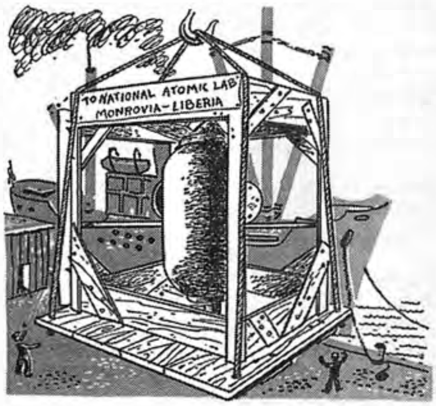
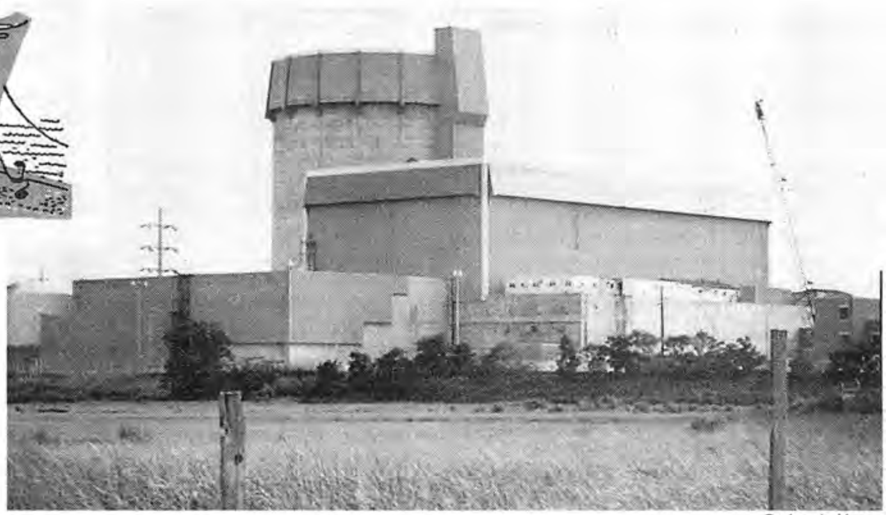


Illustration by George Wilde in Ira M. Freeman, *All About the Atom* (New York: Random House, 1955), p. 123

The promise of nuclear energy for lifting the world's population out of poverty, was cut short by the anti-population, anti-science movement of the 1970s. In the 1950s and 1960s, the "Atoms for Peace" spirit pervaded popular culture, as this illustration from a 1955 children's book shows. Two and a half decades later, Shoreham, a fully ready nuclear plant, was a victim of anti-nuclear pressure on Long Island, New York, and shut down despite the need for electrical power.



Carlos de Hoyos

tribution at the early 1960s, the average global exposure from nuclear weapons tests (0.113 mSv in 1963) was much smaller than medical exposure. The exposure from the civilian nuclear power cycle has been steadily growing since 1955, reaching a trifling value of 0.002 mSv in 2000.

Time for a Realistic Policy

Man's contribution to the contents and flows of radionuclides and of radiation energy in the environment comprises a tiny fraction of the natural contribution. In some areas in the world, the natural radiation doses to man, and to other biota, are many hundreds of times higher than the currently accepted dose limit for the general population. No adverse health effects have been found in humans, animals, and plants in these areas.

In the future reconstruction of the edifice of radiation protection, that now stands on the abstract foundations of the linear no-threshold, a down-to-earth approach will be necessary, taking into account apparently safe chronic doses in the high natural radiation areas, rather than the statistical variations around an average global value. It seems, therefore, that studies of these areas deserve a special attention and support in the coming years.

The 20th century witnessed the dawn of man-made ionizing radiation and radioactivity, the use of this advanced human knowledge to kill people in Hiroshima and Nagasaki, and the greatest nuclear catastrophe in Chernobyl. This 1986 catastrophe has claimed only about 30 deaths of nuclear workers, and probably none, or perhaps one, among the public. This proves that nuclear energy is a comparatively safe means of producing power.

It has also been documented that high, semi-acute radiation doses can cure cancers, and that small chronic doses of radiation are beneficial for health. Man's discovery of "new" radiation, and of radioactivity, which opened the door to unlimited energy sources, is similar to the discovery of fire some 500,000 years ago. Fire made man the most ubiquitous species and enabled expansion of life outside the Earth's biosphere. It took our ancestors many thousands of years to mentally adapt to fire, sometimes even deifying it. It seems that one century has not been enough for such adaptation to ionizing radiation and radioactivity. But there is hope: discoveries today are developing much faster than in the past.

Dr. Jaworowski (jaworo@clor.waw.pl) is a professor at the Central Laboratory for Radiological Protection in Warsaw, and a leading expert worldwide on the effects of radiation. A multidisciplinary scientist, he has studied pollution with radionuclides and heavy metals, and he has served as the chairman of UNSCEAR.

This article is adapted from a presentation he prepared for the International Conference on Radiation and Its Role in Diagnosis and Treatment, held in Tehran, Iran, Oct. 18-20, 2000.

Acknowledgements

Thanks are due to Prof. S. Chwaszczewski, Prof. L. Dobrzynski and Dr. A. Strupczewski for helpful discussions and assistance.

Notes

1. The names of all victims are recorded in "Book of Honor of Roentgenologists of All Nations," published in Berlin in 1992 (Molineus, Holthusen, and Meyer, 1992).
2. For a more detailed explanation, see the author's article "A Realistic Assessment of Chernobyl's Health Effects," *21st Century*, Spring 1998.

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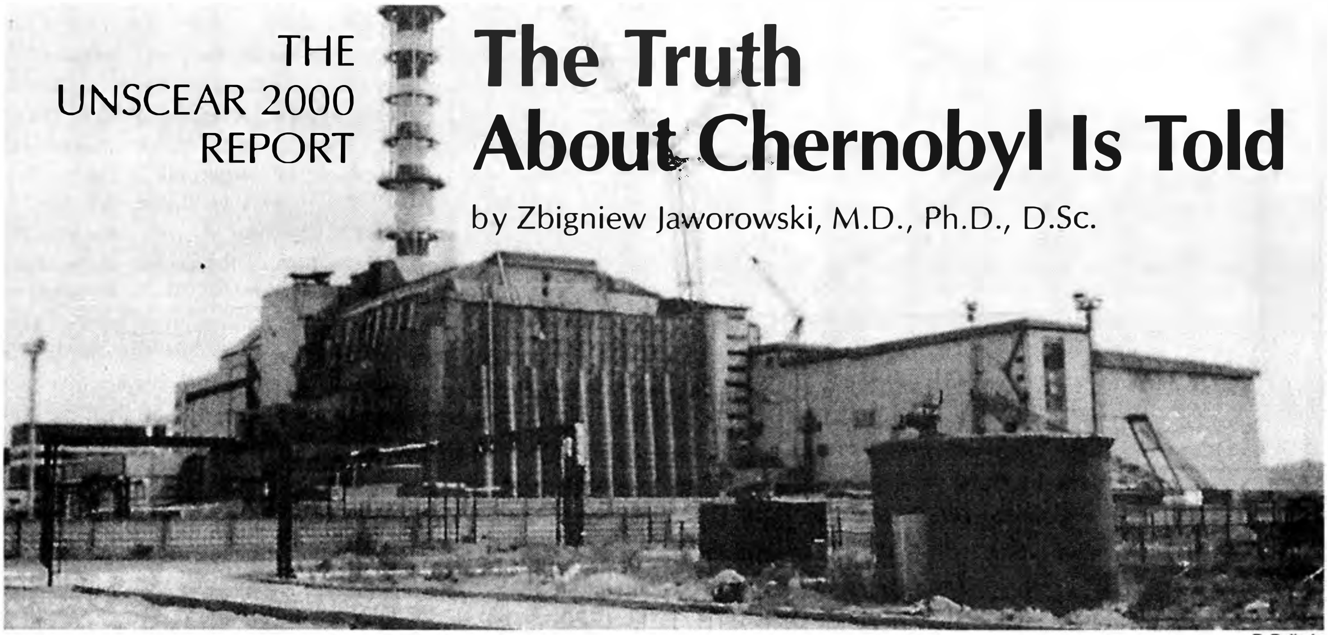
THE UNSCEAR 2000 REPORT

The Truth About Chernobyl Is Told

by Zbigniew Jaworowski, M.D., Ph.D., D.Sc.



P. Pellerin

The Chernobyl accident is still surrounded by anti-nuclear lies and fear. Here, the damaged reactor, photographed in 1992.

The recent report of the United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR) is in total disagreement with the opinions widely propagated by the international media, by the Greens, and by the governments of Belarus and Ukraine, that there have been tens of thousands of cancer deaths and epidemics of genetic disorders, allegedly caused by the Chernobyl accident. To the contrary, UNSCEAR states, even among the progeny of the survivors of the atomic attacks on Hiroshima and Nagasaki, who received radiation doses hundreds of times higher than the radiation doses to the inhabitants of regions contaminated by the Chernobyl accident, *no radiogenetic disturbances of health have been found.*

UNSCEAR's 1,220-page *magnum opus:* "Sources and Effects of Ionizing Radiation," subtitled "The *UNSCEAR 2000* Report to the General Assembly, with Scientific Annexes," was published in September. The report to the General Assembly itself is short, only 17 pages, which serves as a non-technical summary of the 10 technical appendices.

These 10 annexes present an in-depth review of the current state of research on radiation levels and effects, based on 5,400 scientific references.[1] The total report represents the work of 146 committee members of 21 national delegations to UNSCEAR, and of the organization's 15 scientific staff and consultants, over the past six years.

The two most important points that the report makes to the General Assembly are first, a comparison of the radiation doses that an average inhabitant of the Earth receives from all types of natural and man-made sources; and second, an estimate of the health effects caused by the Chernobyl accident, probably the largest possible catastrophe that can occur at a nuclear power station. This juxtaposition offers the reader a way to realistically compare man-made radiation hazards, such as Chernobyl, with the everlasting and ubiquitous natural radiation.

Both issues are "hot." Comparison of doses may influence the future foundations of radiation protection principles and regulations. The report's appendix on Chernobyl (115 pages and 558 references) is obviously politically incorrect: *it denies the claims of a mass health disaster caused by radiation in the highly contaminated regions of the former Soviet Union.*

At the global scale, as the report shows, the average natural radiation dose is 2.4 mSv per year, with a "typical range" reaching up to 10 mSv. However, in the Annex on natural radiation, UNSCEAR presents data indicating that this dose range in some geographical regions is many tens and hundreds times higher than the *average* natural global dose, or than the currently accepted annual dose limits for general population (1 mSv) and occupationally exposed people (20 mSv).

No adverse health effects related to radiation were ever observed among people exposed to such high natural doses. This strongly suggests that the current radiation standards are excessively, and unnecessarily, restrictive.

Radiation Disease and Chernobyl

To estimate the health effects of the Chernobyl accident, one should take into account information on radiation doses absorbed by the exposed populations involved, and the results of epidemiological studies. According to *UNSCEAR 2000,* 134 employees of the Chernobyl nuclear power station and rescue workers, who developed symptoms of acute radiation disease, received doses between 800 to 16,000 mGy. Among them, 28 persons died, as the result of various forms of acute radiation disease, and two more persons died as a result of thermal and mechanical injuries. Although the average radiation dose received by the 381,000 emergency workers after the accident, called "liquidators," between 1986 and 1989 was 113 mSv, *no increase of cancers and leukemia occurred in this group.*

In 1986, some 116,317 persons were evacuated from contaminated regions of Belarus, Russia, and Ukraine. After 1986, about 220,000 additional persons were

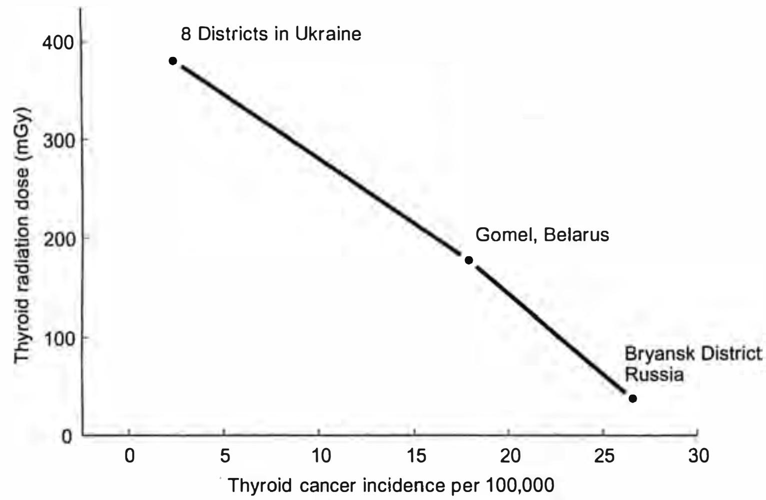


Figure 1

MAXIMUM THYROID CANCER INCIDENCE RATES IN CHILDREN IN HIGHLY CONTAMINATED REGIONS, COMPARED WITH RADIATION DOSE

Shown are the maximum thyroid cancer incidence rates in children in highly contaminated regions of Belarus, Russia, and Ukraine, who were under 15 years old at the time of diagnosis, compared with average thyroid radiation doses. As can be seen, the area with the lowest *radiation dose has the* highest *incidence of thyroid cancer.*

Thyroid cancers are 90 percent curable. As of this writing, only one of these children has died.

Source: Adapted from *UNSCEAR 2000*, Annex J, Tables 40 and 57

relocated, and relocation continued until 1992. In all, about 336,000 persons were resettled, incurring enormous costs to the country, and bringing great suffering to the people involved. There were actually plans to relocate 850,000 people, which fortunately were not fully realized.

The basis for the resettlement was, first, the possibility that those people living in the most contaminated areas would absorb a lifetime whole body dose (that is, their total dose received over a period of 70 years) higher than 350 mSv, which is about double the average global natural radiation dose. Later, this lifetime limit was lowered to 150 mSv, and then to 70 mSv (1 mSv per year).

The decision on relocation was completely unnecessary and, in fact, counterproductive to the health and well-being of the involved population; it was taken in 1990 by the Supreme Soviet, under pressure from the pseudo-experts coming from ecological, populist, and nationalist groups.[2]

According to Prof. Leonid Ilyin, the Soviet scientist who was a member of the group overseeing the rescue operations, a temporary evacuation was probably necessary for about 50,000 people, in addition to a special case of 49,360 inhabitants of the city of Pripyat, very close to the plant. In fact, the decision to evacuate Pripyat was not based on the actual contamination of the city (the lethal fallout covered about 0.5 km^2, in two patches extending up to 1.8 km from the reactor, and did not reach Pripyat). The decision was made based on the suspicion that the burning reactor core might melt the concrete floor on which it was standing and fall into cellars below, which may have been filled with a large amount of water. In this case, an enormous vapor explosion might have sent vast amounts of radionuclides into the atmosphere, thus endangering the inhabitants of Pripyat. Fortunately, as became known later, there was no water in the cellars.

Thus, in the special case of Pripyat, one can say, that the early decision to evacuate the inhabitants of Pripyat was well conceived, and correctly performed. But most of the other evacuations were unnecessary, erroneous, and harmful.

The ultimate cause of these unnecessary relocations was the principle of the linear, no-threshold (LNT) relationship between radiation dose and health effects, which is accepted as the gospel of the International Commission of Radiological Protection (ICRP).

LNT to Blame

The ICRP bases its recommendations for protection of the public in radiation accidents on the LNT. These recommendations—the lifetime limits of 350 mSv and 150 mSv—were used by the Soviet decision-makers, even though they are lower by a factor of 4 to 40 than the natural lifetime doses in many countries of the world, which have been inhabited for thousands of years.

People who were evacuated in 1986, received an average, whole-body radiation dose of 20 mSv, and a dose to the thyroid (from iodine-131) of 470 mSv. Inhabitants of the most highly contaminated parts of Belarus, Russia, and Ukraine, where deposition of cesium-137 was higher than 555 kBq per m^2, received the whole body doses of 47 mSv, 36 mSv, and 83 mSv, respectively. The average doses to the thyroid in the most contaminated regions were 177 mGy in the Gomel district (Belarus), 37 mGy in the Bryansk district (Russia), and 380 mGy in the 8 most contaminated districts of Ukraine.

The Thyroid Cancer Hoax

In its final conclusions on the health effects of the Chernobyl accident, the UNSCEAR report stated the following:

"The number of thyroid cancers (about 1,800) in individuals exposed in childhood, in particular in the severely contaminated areas of the three affected countries, is considerably greater than expected based on previous knowledge. The high incidence and the short induction period are unusual. Other factors may be influencing the risk."

One of these factors are what are called "occult" thyroid cancers, those detected at autopsies by histological studies, and which do not cause visible clinical disturbances during the person's lifetime. These occult thyroid cancers occur *en masse* all over the world. For example, in Canada their incidence is 6,000 per 100,000 population; in Poland it is 9,000; in the United States 13,000; and in Finland 35,000. The highest incidence of thyroid cancers in children found in Russia, before the Chernobyl accident, was 26.6 per 100,000; in Belarus, 17.9;

Courtesy of Dr. Ronald Chesser

Contrary to the scare stories about a nuclear wasteland, the most contaminated region around Chernobyl is now a magnificent nature preserve, with abundant flora and fauna.

and in Ukraine, 4.9. Thus, the potential for the discovery of "excess" thyroid cancers, after the intense health screening that took place after the accident, is enormous.

According to UNSCEAR data, the increase in thyroid cancers diagnosed in children under 15 years old, began to be seen as early as 1987 in Russia, and in 1990 in Belarus—that is, only one year and four years after the accident. However, the latency time for radiation-induced solid cancers, such as thyroid cancer, is about 10 years. According the data presented in the *UNSCEAR 2000* report, there is no relationship (or rather there is an inverse one) between the registered incidence of thyroid cancers in children, and thyroid radiation doses to the population in contaminated areas (Figure 1).

No Increase in Cancers

Finally, UNSCEAR concludes: "Apart from the increase in thyroid cancer after childhood exposure, no increases in overall cancer incidence or mortality have been observed that could be attributed to ionizing radiation. The risk of leukemia, one of the main concerns (leukemia is the first cancer to appear after radiation exposure, because of its short latency time of 2 to 10 years), does not appear to be elevated, even among the recovery operation workers. Neither is there any proof of other non-malignant disorders that are related to ionizing radiation. However, there were widespread psychological reactions to the accident, which were due to fear of the radiation, not to actual radiation doses."

"Finally," the report continues, "it should be emphasized that . . . the vast majority of the population need not live in fear of serious health consequences from the Chernobyl accident. For the most part they were exposed to radiation levels comparable to, or a few times higher than, the natural background levels. . . . Lives have been disrupted by the Chernobyl accident, but from the radiological point of view and based on assessment on this Annex ('Exposures and Effects of the Chernobyl Accident'), generally positive prospects for the future health of most individuals should prevail."

The future will see what prevails: the diligent, objective, scientific judgment of UNSCEAR, which is the most competent scientific body worldwide on radiation matters, or the ideologically and politically motivated propaganda of fear.

Zbigniew Jaworowski, a former chairman and current member of UNSCEAR, is a leading expert on the effects of radiation. He is a professor at the Central Laboratory for Radiological Protection in Warsaw.

Notes

1. The 10 annexes discuss dose assessment methodologies; exposures from natural radiation sources; exposures to the general population from man-made sources; medical and occupational exposures; DNA repair and mutagenesis; effects of low-level radiation doses; combined effects of radiation and other agents; epidemiology of radiation-induced cancers; and exposures and effects of the Chernobyl accident.
2. For more details, see Z. Jaworowski, "A Realistic Assessment of Chernobyl's Health Effects," *21st Century*, Spring 1998, pp. 14-25.

Courtesy of Dr. Ronald Chesser

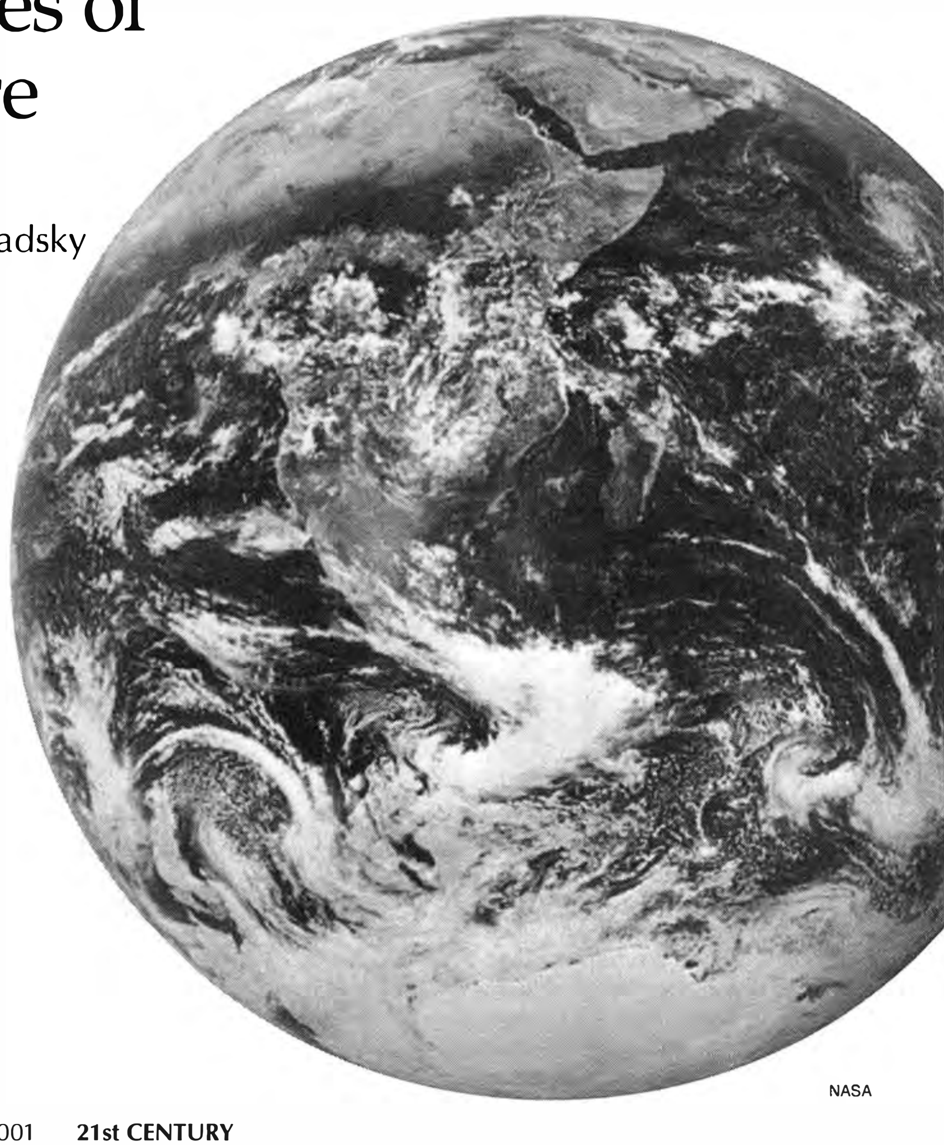
The scientists who have monitored the status of the contaminated area around Chernobyl, have argued on the basis of the development there, that the regulatory standards for radiation exposure for animals and plants should be higher than those for human beings. Here, Chernobyl's swans (left) and storks.

Problems of Biogeochemistry II

On the Fundamental Material-Energetic Distinction Between Living and Nonliving Natural Bodies of The Biosphere

by Vladimir Ivanovich 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.



NASA

Vladimir Ivanovich Vernadsky (1863-1945), who developed the concept of the biosphere and how man's creativity has changed it into the noosphere.

EDITOR'S NOTE

An introduction to this translation appears in the editorial section, page 2. The article was translated from the Russian by Jonathan Tennenbaum and Rachel Douglas. An abridged translation into English, by Vernadsky's son, George, appeared in the June 1944 Transactions of the Connecticut Academy of Arts and Sciences.

Two systems for the transliteration of Russian into English are used here: The bibliographical references in the notes are given in the Library of Congress system. In the text, the transliteration is modified to better approximate Russian pronunciation.

Translator's notes are included in brackets. The numbered footnotes are V.I. Vernadsky's. His parenthetical references to "Sections" refer to the numbered sections of this article.

Foreword

Three years have passed before the author has been able to return to *Problems of Biogeochemistry.*[1] Having been at work recently on the book, *The Basic Concepts of Biogeochemistry in Connection with the Scientific Comprehension of Nature,* the author considers it useful—without waiting for its completion, which will necessarily be delayed—to split off and develop separately in *Problems of Biogeochemistry,* certain specific questions, touched upon in the book, to which he finds it necessary to draw attention right away. One such problem, empirically established by the author in this second issue of *Problems of Biogeochemistry,* is the fundamental material-energetic distinction of living matter in the biosphere, from all other of the biosphere's natural objects and occurrences; a distinction that admits of no exception.

The author has approached this question, starting from the study of life as the totality of all living organisms on the planet—that is, the planet's living matter—, taking into account the special structure of the domain, inhabited by living matter—the biosphere, the sole area of the planet, which is lawfully connected with the expanses of cosmic space. It seems to the author, that before now no one has approached the phenomena of life from this side, yet this new approach leads to major consequences, which can be verified by experience and observation. The author considers, that the table published below includes no hypotheses or theories, but rather constitutes an exact presentation of scientific facts and empirical generalizations flowing from those facts. The table does not depart from the framework of science into the domain of philosophical notions, but at the same time it sharply and decisively reveals the significance of life—living matter—in the biosphere, as a planetary phenomenon.

In connection with the general questions raised here, the author, in a third issue now in preparation for publication, poses the still more general question of "the states of physical space," which concerns not only biogeochemistry, but all investigations of Nature, and which is inseparably connected with the problems of biogeochemistry. The author hopes to publish it in the near future. The topics of these two publications are closely connected.

—Moscow, September 1938

I. Basic Concepts

Living matter, the biosphere as an envelope of the planet. Its new geological state—the noosphere. Natural bodies and the natural phenomena of the biosphere—inert, living, and bio-inert. Their system—the scientific apparatus. Left-handedness and right-handedness in living matter as a manifestation of the state of the space it occupies. The free energy of the biosphere as a manifestation of the biogeochemical energy of the living matter in the biosphere.

1 In my biogeochemical work, which I have pursued systematically and without interruption since the beginning of 1916, I have recently framed conclusions, which point to the deep, unbridgeable distinction—energetic-material in character—between the phenomena of life, and all other processes, occurring in the biosphere; a distinction which, on the one hand, can be expressed with quantitative precision, but which, on the other, calls for new mathematical work in the domain of geometry. Revealed before us, is a new area of the study of life phenomena, which uncovers new facets of the phenomena of life and new possibilities for scientific work. I therefore consider it useful to call attention to these conceptions, rather than waiting for the completion of my reworking of biogeochemistry.

2 The foundations of biogeochemistry are formed from a few basic conceptions, which *do not contain any hypotheses*, but are precise and clear scientific concepts—scientific empirical generalizations of the naturalist's experience and observation. Above all, the very concept *of the living matter of the biosphere* represents such an empirical scientific generalization—one that is as indisputable as a correctly, scientifically established fact. *The living matter of the biosphere is the aggregate of all its living organisms.*

In the following I shall use, instead of the concept *"life,"* the concept *"living matter"* in the indicated sense.

From the standpoint of the biosphere, the individual living organism is usually lost from view; in first place comes the aggregate of organisms—living matter. In biogeochemistry, however—in some strictly defined cases—at times it is necessary to pay attention to the discrete organism, to its individuality. It is indispensable to do this in those cases, where the activity of Man appears as a geological factor, as we see happening now, and the individual personality sometimes becomes vividly apparent and is reflected in large-scale phenomena of a planetary character. The human personality changes, accelerates, and causes geological processes of enormous significance, through its presence in the biosphere.

We are living in a brand new, bright geological epoch. Man, through his labor—and his conscious relationship to life—is transforming the envelope of the Earth—the geological region of life, the *biosphere*. Man is shifting it into a new geological state: Through his labor and his consciousness, the biosphere is in a process of transition to the *noosphere*.[2] Man is creating new biogeochemical processes, which never existed before. The biogeochemical history of the chemical elements—a planetary phenomenon—is drastically changing. Enormous masses of new, free metals and their alloys are being created on Earth, for example, ones which never existed here before, such as aluminum, magnesium, and calcium. Plant and animal life are being changed and disturbed in the most drastic manner. New species and races are being created. The face of the Earth is changing profoundly. The stage of the noosphere is being created. Within the Earth's biosphere, an intense blossoming is in process, the

Courtesy of the History of Geology Department, Vernadsky State Geological Museum, Russian Academy of Sciences

Vernadsky with his students, around 1905. From left, seated: V.M. Tsebrikov, E.D. Revutskaya, S.P. Popov, Vernadsky, Ya. V. Samoilov; standing: V.V. Karandeyev, N.I. Surgunov, V.V. Arshinov, N.N. Bogolyubov, G.O. Kasperovich.

further history of which will be grandiose, it seems to us.

In this geological process—which is fundamentally biogeochemical—a single individual unit of living matter, out of the totality of humanity—a great personality, whether a scientist, an inventor, or a statesman—can be of fundamental, decisive, directing importance, and can manifest himself as a *geological force.* This sort of manifestation of individuality in processes of enormous biogeochemical importance, is a new planetary phenomenon. It emerged, and began to manifest itself ever more sharply and profoundly in the course of time, *during the most recent tens of thousands of years,* on the background of billions of years of the prior history of the biosphere, when this phenomenon did not exist.

Courtesy of the History of Geology Department, Vernadsky State Geological Museum, Russian Academy of Sciences

Vernadsky and his protégés, around 1911. From left, seated: V.V. Karandeyev, Vernadsky, P.K. Aleksat; standing: G.O. Kasperovich, A.E. Fersman (the most famous of his followers).

In biogeochemical processes—outside the boundaries of these phenomena—the totality of living beings—living matter, continues to play the basic role. It is characterized as the totality of all organisms, mathematically expressed as the totality of *average* living organisms. Biogeochemistry studies, above all, the manifestation of the totality, not of the average indivisible unit. In the majority of the other biological sciences, we chiefly study the average indivisible unit; and, in the sciences of medicine and animal husbandry, the indivisible unit, individuality, or the single personality has been of outstanding significance during the past millennia.

Morphologically, living matter is manifested in biogeochemistry as a species, genus, race, etc. We distinguish *homogeneous living matter—belonging to a genus, species, etc.—and heterogeneous living matter,* such as the forest, the steppe, or a biotic community in general, consisting of homogeneous forms of living matter, in certain proportions.[3] The convenience of this approach to the phenomena of life lies in the fact that we do not stray, in our judgments and conceptions, into the shaky domain of hypotheses and philosophical constructs about life, such as dominate the thinking in biology. We do not depart from the domain of scientific facts and scientific empirical generalizations; we stand on their firm ground.

3 Alongside the concept of living matter, we put forward two other empirical generalizations: the concept of the *medium* of life, as the *biosphere,* and the concept of a *living natural body.* Living matter is found on our planet only in the *biosphere,* which is the domain of life.

This characterization defines the boundaries of the biosphere with absolute precision. According to this definition, the entire *troposphere* of the atmosphere belongs to the biosphere. And now, living organisms—human beings and their inevitable companions: insects, plants, and microorganisms—are penetrating even higher, by themselves or with mechanical assistance, into the *stratosphere.* At the same time, civilized humanity (together with its inevitable living companions) is penetrating several kilometers below the surface of the Earth, deep below the limits of that surface terrain, which is in contact with the troposphere. Today, too, we recognize the planetary significance of the discovery, at the end of last century, that life—chiefly anaerobic, microbial living matter—is to be found in subterranean regions more than three kilometers deep, and probably deeper. The lower boundary of the biosphere thus lies several kilometers below the surface of the geoid.[4] The entire world ocean belongs to the biosphere.

The biosphere constitutes a definite *geological envelope,* sharply differentiated from all other geological envelopes of our planet.[5] This is so, not only because the biosphere is populated by living matter having enormous significance as a geological force, completely reworking the biosphere and transforming its physical, chemical, and mechanical properties. In addition, this is the sole envelope of the planet, penetrated in an appreciable way by cosmic energy, which transforms it even more than living matter does. The main source of this energy is the Sun. The Sun's energy—thermal, light, and chemical [i.e., ultraviolet—trans.] energy—is, together with the energy of the chemical elements, the primary source for the creation of living matter.

Living matter permeates the entire biosphere and to a large extent creates it. Living matter accumulates the energy of the biosphere, mainly the thermal and chemical energy of solar radiation and the chemical energy of the Earth's atoms. It is possible, that radioactive energy plays a certain role in this.[6]

4 Materially and energetically, the matter constituting the biosphere is acutely heterogeneous. From this standpoint, we must distinguish the main bulk of its matter, which does not belong to living matter, and which I shall call *inert*—nonliving matter. The greater part of this, in terms of weight, consists of solid rocks. But the greatest volume belongs to liquid and gaseous bodies—the ocean and the atmosphere. Here is found—here lives—the totality of the planet's living organisms—its living matter.

Between the living and inert matter of the biosphere, there is a single, continuous material and energetic connection, which is continuously maintained during the processes of respiration, feeding, and reproduction of living matter, and is necessary for its survival: *the biogenic migration of atoms* of the chemical elements, from the inert bodies of the biosphere into the living natural bodies and back again. This appears in the form of *motion*—the departure and arrival of specific chemical compounds and elements to and from living organisms in connection with the processes of feeding, respiration, excretion, and reproduction, characteristic of living matter. These processes define the *biogeochemical energy* of living matter, the chief manifestation of which is the multiplication of living matter.

All of these manifestations of biogenic migration and biogeochemical energy are determined by the dimensions, the chemical composition, and the energy of the biosphere. For this reason, not any arbitrary sorts of organism can exist in the biosphere, but only those organisms strictly determined by the structure of the biosphere. *The living organism and living matter are a lawful function of the biosphere.* People usually forget this. And, in an erroneous manner—especially in philosophical discourse, but also in biology—they counterpose the living organism to its environment, as if these were two independent objects. This sort of counterposition is a logical error. It is especially apparent in philosophy, and *undermines at the core a great number of its conclusions.* I shall not pause here to consider this point more fully.

5 No less important, is the concept of a *natural body.* Strangely enough, this basic concept, which in essence pervades all natural science, is usually ignored and not subjected to serious logical analysis. And yet, scientists use the concept, almost unconsciously, at every step of their work.

In my youth, I had a clear and conscious experience of its importance. My teacher V.V. Dokuchayev, in his creative work on soil science, put forward the proposition, that soil is a *special natural body,* distinct from other rocks. As is well known, he proved this thesis, and thus made it possible for his contemporaries to grasp, through a striking example of a successful synthesis, the bases of creative work in natural science.[7]

But such events are rare in the history of science and in current scientific life. Normally, debates do not address the fundamental assumptions of scientific knowledge. People do not talk about these assumptions; they forget about them.

Reflecting on this, it is easy to convince oneself, *that all natural science is based upon the concept of a natural body, or a natural phenomenon.* In our further discussion, we shall deal only with the biosphere, and shall consider phenomena involving living matter.

Scientists study in the biosphere only those objects, which are created in the biosphere by forces occurring within the biosphere, or phenomena, produced in the biosphere by those forces. The objects they deal with, may conveniently be termed the *natural bodies* of the biosphere, and the phenomena—*its natural phenomena.* The task of science is to enumerate, describe, and identify all the natural bodies and all the natural phenomena, which exist or have existed in the biosphere. This is the work of generations of scientists, and there are billions of billions of scientific facts and scientific generalizations—i.e. natural bodies and natural phenomena—to be grasped in a scientific manner, counted, and brought into a system. These form the basis of science; from them, empirical generalizations are constructed, which can be brought back once again to the natural bodies and natural phenomena.

This work results in the creation of the basic content of science, for which, strangely, there is not yet any generally accepted expression. I have had to name it, and, perhaps, it is convenient to call it *the scientific apparatus.*[8] This apparatus began to be created in astronomy already thousands of years B.C., and was understood—it came down to us—in the form of numerical data on the positions of the Sun, the stars, and the planets in the Hellenistic compendia (Hipparchus, Ptolemy). This work was revived in the Middle Ages in Central Asia. Everywhere, it was done in the chronicles in the form of precise records of comets, fireballs, meteorites, etc. Starting in the 16th century, there was a rapid accumulation of data, the evaluation of which was the basis for making the first major generalizations. But even in astronomy, the basic forward motion, which has been continuous and developing rapidly from that time on, began on a large scale only in the 18th century. In that century—the century of *descriptive natural science*—the effort to precisely enumerate, observe, and describe every natural body and to record every natural phenomenon, became a conscious task of exact natural science.

Linnaeus (1707-1778), basing himself on the work of earlier naturalists, introduced the concept of the *system of Nature* and for the first time calculated the number of species of animals and plants—the species of homogeneous forms of living matter, inhabiting the biosphere. In 1758, he knew a total of 4,162 species of animals (by 1768, the number was 5,936), and in 1768—7,788 species of plants. In all, Linnaeus had distinguished 13,724 species of living organisms by 1768, and even fewer rocks and minerals. Today, the number of species of plants is approaching 200,000, and may possibly exceed 300,000. The number of species of animals is approaching 800,000; in reality, it is probably several million and may reach 10 million. In essence, the *"system of Nature,"* understood in a broad sense, corresponds to what I call the scientific apparatus.

The colossal quantity of numerical data, corresponding to chemical and physical properties of matter—growing like a snowball, always increasing over the course of time, obtained mainly by *scientific experiment,* rather than from observation of the biosphere, and first created in the biosphere by scientific work, exceeding by many times the quantity of living natural bodies and living matter, and having no limits—in my opinion, makes it logically unclear, inconvenient, and practically useless to term these data a system of Nature. Therefore, the concept of *the scientific apparatus,* which we can appreciate, only because it has been reduced to a scientific system, is simpler. It includes both the system of Nature and the scientific apparatus of the humanities, which is encompassable by a scientific system, albeit thoroughly permeated by individuality.

Carl von Linnaeus (1707-1778) introduced the concept of the system of Nature, and calculated the number of species of animals and plants.

6 Every object of natural science is a natural body or natural phenomenon, created by processes of Nature. At the present time many quadrillions, if not more, of natural bodies and phenomena have been scientifically collected, enumerated, and scientifically defined in the system of the scientific apparatus. The number of bodies and phenomena continuously increases, and the system of the scientific apparatus is also continuously being perfected. Thanks to this, we are confronted, ever more acutely, with an infinite quantity of scientific facts to examine. The basic content of science is located in them. Reworked by means of scientific generalization, provisional scientific hypotheses and theories, and embraced by mathematical deduction and analysis, these become *scientific truth,* the precision and profundity of which increases *with each generation.*

This is what distinguishes exact science from philosophy, religion, and art, where *there is no scientific apparatus* and where the scientific truth, sometimes discovered by intuitive creativity, can be recognized as such only when it has been scientifically validated. This creative intuition sometimes comes far in advance of its scientific comprehension, and it is in these domains of human creativity that the scientific truths of the future are hidden, which are unclear to contemporaries. But, we cannot make precise sense of them without science, without grounding them in the scientific apparatus.

7 It is possible to distinguish three types of natural bodies in the biosphere: *living* bodies (for example, a plant, a beetle, etc.), *inert bodies* (for example, rock, quartz, etc.), and *bio-inert* bodies (such as soil, lake water, etc.).

The biosphere consists of sharply bounded domains, formed by living, inert, and bio-inert bodies—waters, living matter, rocks, air, and so forth. A transition from living bodies to inert bodies takes place when they die; when a living body ceases to exist as such, it is transformed into organogenic rock (for example, bioliths) and inert bodies such as gases.[9] Bioliths are often bio-inert bodies. The direct generation of a living organism from inert bodies is never observed: the principle of F. Redi (all life comes from life) [*omne vivum ex vivo*], is never violated.[10]

The concept of inert (dead) and living natural bodies as sharply distinct natural objects, is a commonplace, ancient notion, inculcated over millennia of history—a concept of "common sense." It cannot provoke any doubts, being clear and intelligible to all.

In scientific work, even over centuries, only a few cases can be found, in which there were doubts about whether a specific natural object should be reckoned a living being or an inert body—whether that given natural phenomenon were a manifestation of the living or the nonliving. One such doubtful case—perhaps the most profound one—is the question of viruses.[11]

Other cases may be the questions J.C. Bose has raised in Calcutta, about whether *life* is not manifest in both living and inert matter, but to different degrees. These are, however, philosophical problems, which Bose tried to solve using the scientific method, as G.T. Fechner had posed the matter less precisely, in philosophical terms, earlier in the 19th century in Europe. In this case, the question of biogeochemistry's living matter is not involved, since in biogeochemistry, living matter is the totality of living organisms, whereas Fechner and Bose were trying to delve into the material-energetic substance, which is common to the living and the inert body.

8 The concept of *a bio-inert natural body* is a new concept—defined in exact biogeochemical terms and in distinction from the concepts of inert and living natural bodies. Natural bodies of this sort are clearly expressed in the biosphere and play a big role in how it is organized.[12] *Bio-inert bodies are characteristic of the biosphere.* These are lawful structures, consisting of inert and living bodies

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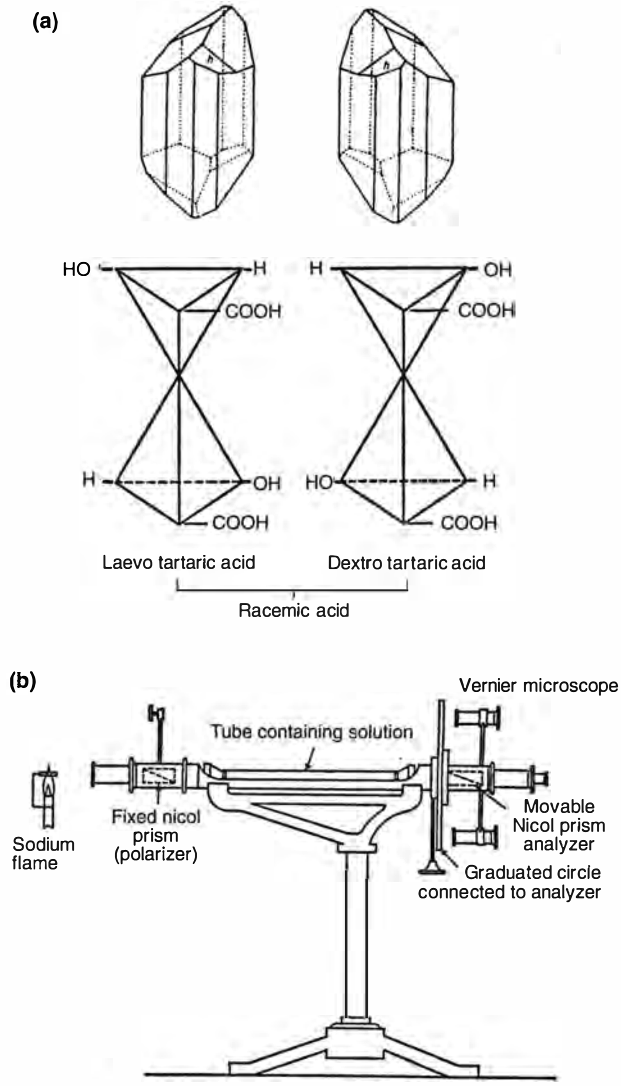

PASTEUR'S DISCOVERY OF OPTICAL ACTIVITY AS A DISTINGUISHING CHARACTERISTIC OF LIFE

In 1848, Louis Pasteur succeeded in separating, by hand, the left- and right-handed forms of tartaric acid crystals (a). Dissolving them in water, and examining the two solutions in a polariscope (b), he found that one solution turned the plane of polarized light to the left, and the other one to the right. He then showed that only the left-handed form is produced in biological processes, such as fermentation, while equal quantities of left- and right-handed forms (racemic solution) arise in laboratory synthesis of the compound.

simultaneously (for example, soils), all of *the physico-chemical properties* of which have to be adjusted—with sometimes very large corrections—if, in studying them, the activity of the living matter located within them is not taken into account.

The biogenic migration of chemical elements (atoms) plays a big role in their properties—very often the dominant role.

Any soil is a typical bio-inert body. V.V. Dokuchayev had already recognized this clearly.

The overwhelming majority of *terrestrial waters* are bio-inert bodies. There are only isolated instances, in which living matter does not play a fundamental role in them. This is not the case, for example, in hot volcanic waters, which are rich in sulphuric and hydrochloric acid, nor is it the case in strongly saline waters. Nonetheless, even in the Dead Sea there is microbial living matter, although it does not play a decisive role. Rain water is free of living matter in its first moments. All the waters of the oceans and seas, of rivers and lakes, and all of their *bottoms,* are bio-inert bodies. The gas balance, the chemical composition, and the silts of all these waters—their chemistry—is basically determined by living matter.

The role of bio-inert natural bodies is extraordinary, and has not yet been properly taken into account in how the biosphere is organized.

The process of *the weathering of rocks* is a bio-inert process—a fact that is usually not considered. This circumstance, I think, explains the backwardness of this area of chemical geology (the weathering of the Earth's crust) relative to the contemporary level of knowledge. The biogeochemical approach should contribute much to the solution of this problem.

9 So far, I have not gone beyond the concepts: living matter, the biosphere, natural bodies, and natural phenomena (inert, living, and bio-inert)—concepts based on the enormous empirical, precise material of experience and observation. These concepts cannot arouse any theoretical doubts whatsoever, nor do they require any new scientific hypotheses or theoretical scientific constructions to be understood. One can calmly proceed with the work, so fruitful for science, of systematizing the accumulated scientific facts and generalizing from them.

But, for an understanding of the matters that now follow, I must necessarily touch upon two new phenomena of great importance, the scientific investigation of which cannot be carried out on the basis of the mere generalization of scientific facts, but requires introducing new concepts and finding a new form of comprehension of the facts. Both of these phenomena are extremely poorly understood from a theoretical standpoint, and their scientific significance has not been appreciated. They are now on the frontier of contemporary scientific knowledge. These are, first, the concept of *right- and left-handedness* and, second, the concept of *biogeochemical energy*.

Right- and left-handedness is an everyday concept, existing since the earliest times, which has hardly been comprehended in a scientific and philosophical way. It was Louis Pasteur, who first drew attention to its paramount importance for understanding the phenomena of life—the living organism, or living matter. Independently of Pasteur, and somewhat earlier, Bechamps had realized this, but Pasteur grasped the question more deeply, and identified within it phenomena, which permit us to penetrate in a precise scientific way into this immense domain of problems, the full significance of which Pasteur himself could not foresee.

The concept of *biogeochemical energy* was introduced by me in 1925, in my report to the Rosenthal Foundation in Paris, which was never published in full. In my book, I deal with this question to the extent possible today. Let us first examine the question of right- and left-handedness in its relation to living matter and to the biosphere.

10 We do not need, here, to deal with the profound naturalist and experimenter A. Bechamps—an older contemporary of Pasteur, his enemy and rival, who outlived Pasteur by many years, but was unable to obtain the conditions needed for systematic work. He started out from exactly the same fact, as did Pasteur—from the discovery, made at the beginning of the 19th century, in a small enterprise in Alsace, of the transformation of racemic acid or its salts into left-tartaric acid during the development of wine mold in it. On this basis, a new way of producing left-tartaric acid was established. Pasteur and Bechamps—both profound chemists—saw in this chemical action of the mold as living matter, a remarkable, exclusive property of life—living matter; something not understood, unusual, unknown and, apparently, impossible in ordinary chemical reactions. To reflect upon this and to take note of it—to see the problem involved—was already a big accomplishment, but it was only the first step. It was necessary to investigate the phenomenon, and express it, in specific scientific facts.

Bechamps's circumstances of life did not permit him to do this. But Pasteur connected the new phenomenon with a very special property of enantiomorphous crystals, characterizing—under the influence of living matter—the racemic acids and salts. As a result of that action, an isomer was produced—only the left- or the right-handed one, but not the other, which had perhaps been consumed by the organism. Pasteur correctly saw in this a drastic violation of the law of crystalline symmetry. This violation appeared in the fact, that the right- and left-handed forms manifest completely different degrees of stability in living matter, exhibiting *far from identical chemical behavior*—something never observed with them in inert natural bodies. Evidently, the latter could not occur.

He called this phenomenon *dissymmetry,* but did not draw attention to, and did not connect this with the normal right- and left-handedness of living matter, in its morphological and physiological structures. He studied the phenomenon as a crystallographer and a chemist, but not as a biologist. Pasteur himself did not provide a more precise definition of dissymmetry and did not consider the changes, which had occurred in crystallography, when he returned to these problems again in the last years of his life.

Much more important, was Pasteur's discovery of *molecular dissymmetry,* completely analogous to the dissymmetry of polyhedral crystals. He thereby initiated a whole new science—stereochemistry. Because of it, chemistry was enriched by the concept of *asymmetry* (i.e. the absence of symmetry in the spatial configuration *in the vicinity* of a carbon atom). This term is used simultaneously in chemistry and physics in completely different senses, generating confusion.

11 The muddle that arose interfered with the work. The molecular dissymmetry, discovered by Pasteur, showed, that the presence of living matter is reflected in the chemical formula, including in solutions, and that *right- and left-handed atomic structures* are found to be non-equivalent in chemical reactions. *They are chemically distinct in living matter, but chemically identical in inert chemical media.* Pasteur did not know, that (as was discovered after his death) this was essentially the same phenomenon he himself had discovered in crystals. For in crystals, he had a spatial distribution of right- and left-handed spiral arrangements of *atoms,* analogous to the atomic structure in molecules. This conclusion emerged in a precise way from the notion of *crystalline space*—speaking in contemporary language—geometrically constructed by Ye.S. Fyodorov and A. Schoenflies at the end of the last century. In the coincidence of the 230 groups he identified (there are actually 219), with the arrangements of atoms in crystalline space, Ye.S. Fyodorov saw proof of the atomic construction of chemical compounds. Finally, this was experimentally demonstrated in the 20th century by the X-ray analysis of crystals. The contemporaries of Pasteur—Seeber, Ampère, and Godin—had foreseen this, but Pasteur remained outside the influence of their ideas.

After Pasteur, P. Curie generalized the concept of dissymmetry, considering the phenomenon, discovered by Pasteur in living organisms, as a special case, and applying the concept of dissymmetry to physical phenomena in general—electric and magnetic fields, etc.—as a fundamental postulate of physics. But Curie was not able to complete the development of his ideas; his work was interrupted in full swing, by his sudden death. No coherent presentation of the results he had obtained was left in his papers. It should only be noted, that Curie demonstrated the existence of different forms of "dissymmetry," and logically concluded that a phenomenon, connected with any given form of dissymmetry,

Courtesy of the History of Geology Department, Vernadsky State Geological Museum, Russian Academy of Sciences

The Russian delegation on the way to the International Geological Congress in Canada, 1913. The photo is taken on the deck of the Empress of Britain, en route from England to Canada. From left, seated: Ya.V. Samoilov, F.Yu. Levinson-Lessing, Vernadsky, F.N. Chernyshev, B.L. Stepanov; standing: M.M. Lyuboshinsky, V.F. Levinson-Lessing.

must have a cause that possesses the same form of dissymmetry. It is convenient to call this conclusion *P. Curie's principle.*

In view of this state of the matter, I think it will be more correct to leave aside the concept and the word "dissymmetry," and instead employ the older, generally familiar idea of the distinction between right- and left-handedness in organisms, which is so starkly manifested in Man. But since there exists a theory (an erroneous one, it seems to me) that right-handedness in Man emerged only in the Neolithic period, the correct way to proceed will be to substitute for right- and left-handedness, the more general concept, which Curie employed before his death, of *distinct states of space.* He did not manage to prepare a formal presentation of this concept before his death, but it essentially corresponds, of course, to the different forms of dissymmetry, one on which Curie and Pasteur were working.

This concept was widely known among naturalists in the domain of descriptive natural science, and is rooted far back in the 18th century. Here the subject was often the variable state of space on our planet, connected with its orbital motion around the Sun; that certain motions and phenomena were different, according to whether they took place on a part of the planet moving in the direction of the Sun, or in the opposite direction. Pasteur recognized the possibility of *different states* of cosmic space, by which he explained his discovery that living matter exhibits dissymmetry. Indeed, we should see in the state of space, the basic *geometrical substrate* for all of its material, temporal, and energetic manifestations.

In the present case, there will be a state of space, in which right- and left-handedness, expressed as right- or left-handed spiral structures of atoms, are chemically identical in inert bodies and distinct in living ones. This, one of the most profound geometrical properties of natural bodies, has been given insufficient attention, in philosophy, mathematics, and natural science. But we are all very familiar with it in daily life. We know it from childhood, since a human being is a living body, in which right- and left-handedness are sharply distinguished from one another (including in chemical terms). For example, one person out of 16,000 [sic] is left-handed. In recent times these phenomena have begun to attract greater, but in my opinion still insufficient, attention in biology.

Mathematicians—especially geometers—can no longer ignore this, but need to elaborate this fundamental *geometrical phenomenon.*

I shall return to the question of the state of space, in general, and in connection with its particular manifestation in the non-equivalence of right- and left-handedness, in my next study on the problems of biogeochemistry. Here I cannot go into it further. It seems to me that it is convenient to speak, in this context, about physical space, as Helmholtz proposed.

12 It is necessary to discuss yet another phenomenon, which has hardly been comprehended by scientific generalizations—*the active energy of living matter in the biosphere.* R. Mayer, almost 100 years ago, took this manifestation of living matter under consideration. He showed that in organogenic minerals—in coal deposits—we have an accumulator of free energy, captured in this form by the living matter of the Carboniferous period, and we use the fossilized solar rays of that time. But the idea in general form—the creation and accumulation of *free energy in the biosphere by* *living matter* and by the natural processes associated with living matter—arose in the minds of many in the middle of the 19th century, when the concept of energy itself was developed.

Now I want to address this more concretely: not as the basic question of the energetics of the planet, but as a biogeochemical problem. In 1925, I designated the free energy exhibited by living matter in the biosphere, which essentially amounts to the work, associated with the motion of atoms, and is manifested in the movements of living matter, as *biogeochemical energy* (See Section 15, V). Since biogeochemical energy sharply distinguishes living matter from inert matter, it is indispensable to mention its basic features here.

13 The biogeochemical energy of living matter is closely linked with three fundamental characteristics of living matter in the biosphere: first, with *the unity of all living matter in the biosphere;* second, with the continuous generation, by living matter in the biosphere, of *free energy, capable of performing work;* and third, with *the colonization of the biosphere by living matter.*

In all three of these cases, the manifestation of biogeochemical energy is different; *taken as a whole, biogeochemical energy is inhomogeneous.* In the final analysis, it is connected with the movement of living matter in the biosphere, with passive or active displacements (relative to living matter), associated with the mobility of masses of living matter in the biosphere, and ultimately reducible to the motion of atoms or chemical elements.

From what I have said, it is clear that biogeochemical energy is not some special form of energy pertaining to life; it is not the *vital energy* that W. Ostwald was looking for—analogous to thermal, chemical, light, electrical energy, etc. It does not affect the law of conservation of energy, but appears in that context as *already known forms of energy.*

We can now trace the real sources of biogeochemical energy with precision. They are, ultimately, the radiant energy of the Sun (light, heat, chemical, and the energy of the chemical elements, from which bodies of living matter are constituted (chemical and thermal energy). There is probably a contribution from radioactive elements.

An exact quantitative calculation of the caloric effect in life processes, I believe, establishes beyond any doubt that such is its origin. It is, essentially, a result of *the organization of the biosphere and the organization of the living matter* that inhabits the biosphere.

I cannot go into this matter further here. I shall only mention the main forms of manifestation of that organization. The most important is *the biogeochemical energy, connected with the colonization of the planet.* I attempted to calculate it in the form of a definite, for each species of living matter, maximum *velocity of that species' transmission of life*—the perhaps unsuccessful definition I gave it earlier; that is, *the velocity of colonization of the entire planet by a given organism.* This is energy, connected with the *reproduction of living organisms.* Each form of living matter can in this way spread throughout the planet and, within a certain period of time, which is different for each form of living matter, theoretically colonize the entire planet. In the most rapid cases, for bacteria, this process of colonization can occur within one to one-and-a-half days; while for the elephant—one of the slowest-reproducing of all organisms—it would take 1,000 to 1,100 years. At full colonization, the living matter would cover the entire surface of the planet, i.e., it would fill all of its actually existing lines and areas. One of these curved lines, the line of the Earth's equator, i.e. the precisely defined terrestrial line (curve) of maximum length, may be taken as a single parameter for comparison, common to all forms of living matter.

When I speak here about the colonization of the planet, I assume that this process of colonization were to occur under such conditions, as would permit it to proceed normally into the future, if it were not hindered by lack of space—of surface area for colonization. The velocity of colonization, expressed as a magnitude **V**, may fluctuate within limits ranging from close to the speed of sound in air, more than 33,000 centimeters per second (for some bacteria), to hundredths of a centimeter per second (for the elephant).

Courtesy of the History of Geology Department,
Vernadsky State Geological Museum, Russian Academy of Sciences

Vernadsky's gravestone in Novodevichye cemetery, Moscow. The sculpture is the work of Z.M. Villensky in 1953; the photo was taken by Yu.Ya. Solovyov.

In other words, we are talking about the long-term, durable colonization of the planet by an organism under its normal conditions of life, in which it can exist over generations; and not about *explosions* of life, in which the excess of organisms born, dies out due to insufficient food or living space.

These conceptions have not yet entered into the consciousness of science. I am convinced that their employment is a matter for the future. It should be noted, that the velocity of sound corresponds to the real condition, wherein the normal composition of the atmospheric medium, in which the organism lives—even in the case of aquatic organisms (natural waters have their own underwater atmosphere)—, is not destroyed. This shows that biogeochemical energy, so expressed, has nearly reached its physical limits. The velocities obtained in this way may be quantitatively compared with one another; it can be asserted, for example, that the velocity of colonization for the elephant is 10^7 times less than for bacteria.

But the biogeochemical energy of colonization does not subsume all the manifestations of that energy. I shall mention two more of its forms here.

First, the creation of *a mass of a living matter* and *its maintenance,* by the metabolic process, *at a constant value* during the period of the organism's existence.

And, second, the enormous new form of biogeochemical energy, constituted in the biosphere by the technical *work process of the human race,* which is directed in a complex manner by human thought—consciousness. It is remarkable, that the growth of machines within the structure of human society, also proceeds in a geometrical progression over the course of time, just as does the proliferation of any living matter, including human beings.

These manifestations of biogeochemical energy have not been scientifically investigated at all.

It is imperative to direct scientific work into these areas of biogeochemistry, not only because of their great theoretical significance, but also, it seems to me, with a view towards their certain importance for the tasks of the state. In biogeochemistry, it is necessary to make a deliberate approach to the spontaneous process of the biosphere's transformation into the noosphere, which is now taking place.

For this, the paramount task is to assemble facts and study the problems connected with biogeochemical energy. I have no doubt that this will be done sooner or later. I hope to come back to it in my book.

The basic, distinctive feature of biogeochemical energy is clearly and forcefully demonstrated in the increase of *the free energy of the biosphere* over the course of geological time, and is evident in an especially drastic manner in the transition from the biosphere to the noosphere, which is now apparent.

II. Table

The Fundamental Material-Energetic Distinction of the Living Natural Bodies of the Biosphere from Its Nonliving Bodies

The distinction of the energetic processes of living matter from those of inert matter is located in the context of the same forms of energy, as appear in inert natural bodies. The chemical composition of both types of natural bodies comes down to the same chemical elements—although it is possible that the atomic weights of some or all of the elements are shifted in living matter. This fundamental distinction is observed in the space-time of forms of living matter. It is indispensable also to study, alongside matter and energy, the manifestation of time in living processes. The scientific hypothesis of a special geometrical structure of space for bodies of living matter is admissible, and requires verification—a space not corresponding to Euclidean geometry, but lying at the basis of the material-energetic and temporal properties of living matter, distinguishing it from the inert natural bodies of the biosphere.

14 On the basis of everything that is currently known about the biosphere, I shall now attempt to express concisely, *without any theories or hypotheses,* that sharp distinction between the living matter of the biosphere, and its inert natural bodies, which is so pronounced and characteristic for the envelope of the Earth, most familiar and closest to us. It seems to me, that this is necessary and important to do right now, before the publication of my book—whenever that might occur. As far as I know, this has never yet been done in such a form and aspect; consequently, it could never before be discussed as a whole—the most important problem lies outside the naturalist's field of vision.

It is extremely important, for naturalists to think about understanding such a fundamental phenomenon in the biosphere.

It is important for them to have at their disposal, not so much the theoretical scientific-philosophical conceptions of life, which today occupy the thought of philosophers, as those exact data, which subsume biology and all of its "definitions of life," grounded in those data.

In the table provided below, I believe I am giving only such empirical generalizations, and that I do not depart from the domain of scientific facts. This is the side of the question, to which attention must now be turned, and these generalizations should be taken as the basis for scientific work.

15 The acute, unbridgeable distinction between living natural bodies and inert natural bodies of the biosphere can be summarized in condensed form in the following table.

The Fundamental Material-Energetic Distinction of the Living Natural Bodies of the Biosphere from Its Nonliving Bodies

Inert Natural Bodies	Living Natural Bodies

I.

Inert Natural Bodies

Among the *dispersed* inert natural bodies of the biosphere, there are no bodies analogous to living bodies. Dispersed inert forms are concentrated in the biosphere, just as living forms are, but the former penetrate to greater depths. Still deeper, evidently in the granite layer of the crust, their existence is stifled by the great pressure.

These inert bodies are created in the biosphere by the death of living matter (for example, microscopic organisms), from their secretions and excretions, through the motion of gases or liquid phases, in winds, moving waters, oils, etc. They are also brought into the biosphere from its lower regions by gases or liquids, volcanic explosions and eruptions, and tectonic movements of deeper layers of the Earth's crust. They are created by ordinary physico-chemical processes and can be synthetically reproduced in our laboratories.

Inert dispersed bodies—cosmic dust and meteorites—penetrate the biosphere constantly and continuously from the expanses of cosmic space, partly from the galaxy.

Living Natural Bodies

Living natural bodies exist only in the biosphere and *only as dispersed bodies,* in the form of living organisms and their aggregates—living matter. They are observed in both the macroscopic (gravitational field), and in the microscopic cutaway views of reality.

The artificial synthesis of a living natural body has never been accomplished. This indicates that some fundamental condition is required for such a synthesis, which is absent in the laboratory. L. Pasteur identified dissymmetry—a special state of space—as the missing condition (Sections 10-11).

The penetration of living natural bodies into the biosphere from cosmic space is conceivable, but has not been proven so far.

II.

Inert Natural Bodies

Inert natural bodies are extremely diverse and, taken as a whole, manifest no unifying genetic connection among them.

The inert natural bodies of the biosphere have no common, unifying feature analogous to the cell, protoplasm, and reproduction—features common to all living natural bodies.

Living Natural Bodies

Living natural bodies represent a unified *whole—the living matter of the biosphere*—both *morphologically,* having *a single morphological unit—the cell;* as well as *in their material structure,* having the same *protoplasm;* and, finally, *in dynamic terms, as always possessing the ability to reproduce.*

It can hardly be denied, that such a unity of all living natural bodies, is connected with their genetic unity in the course of time.

III.

Inert Natural Bodies

In inert natural bodies and natural phenomena, there is no distinction in the chemical properties between the left- and right-handed forms of one and the same chemical compound. In inert bodies these are chemically identical. Right- and left-handedness are subject to the strict laws of symmetry for homogeneous solids (monocrystals). In particular, the quantities of right- and left-handed monocrystals of one and the same chemical compound, formed simultaneously in an inert medi-

Living Natural Bodies

A chemical distinction between right- and left-handed forms of the same chemical compound, characterizes the state of *the physical space,* occupied by the body of a living organism, and its manifestation in the surrounding medium, in the biosphere. This chemical non-identity is strongly manifested in the solid (crystalline and mesomorphic) and liquid products, formed by biochemical processes. Either right-handed, or left-handed isomers predominate. This phenomenon is acutely and profoundly manifested in the properties of the living matter of the biosphere, right down to the molecules which make up living bodies. The

Inert Natural Bodies	Living Natural Bodies
um—are identical. "Dispersed droplets," i.e. homogeneous crystalline polyhedra—individual specimens of a solid chemical compound—may differ strongly in their internal structure from the usual (isotropic) space of Euclidean geometry, but they do not depart from the framework of that geometry. Right- and left-handedness are geometrically and chemically identical in inert natural bodies. Both are always present in the same number, and are chemically indistinguishable. One can state, that this chemical identity of the right- and left-handed forms, is a necessary *manifestation* of the *atomic* construction of homogeneous, solid chemical compounds, and of Euclidean physical geometrical space, materially expressed in this way. It is a manifestation of the atomic construction, on the one hand, and of Euclidean geometry, on the other.	laws of symmetry for the solid crystalline state of matter are violated in a drastic manner. Such states of space, occupied by bodies of living matter, are created in the biosphere only out of previously existing living natural bodies. They are generated by *birth* (Redi's principle). One can see here an expression of Curie's principle (Section 11). It appears that L. Pasteur was right, that *for the primary chemical compounds, essential to life, only the left stero-isomers* exist inside the body of a living organism (in its physical space); the right-handed isomers either do not appear, or are eliminated by the organisms. Unfortunately, until now this enormously important phenomenon, which could easily be established, has still not been verified, and remains only very probable.

IV.

Inert Natural Bodies	Living Natural Bodies
New inert natural bodies are created in the biosphere by physico-chemical and geological processes, irrespective of earlier existing natural bodies, living or inert; they are formed via innumerable pathways from natural bodies, which usually do not resemble the resulting product. Inert bodies can be formed within living natural bodies. But there is nothing resembling reproduction in the creation of inert natural bodies in the biosphere. There is no kind of change in inert natural bodies of the biosphere, analogous to the evolutionary process of living matter. Generally speaking, we see in the biosphere today the very same inert natural bodies and the same phenomena of formation of such bodies, as have existed over a period of at least two billion years. In the course of geological time, new inert bodies emerged only under the influence of the evolutionary process of living matter. The creation of such new inert bodies is occurring in a drastic and powerful way—and their significance is growing—in the *noosphere* of the present epoch, as a consequence of human creativity.	A new living natural body, a living organism—is born only from another living organism like it. For each species of living matter there is an alternation of *generations,* coming to be at a certain definite rate over time (Redi's principle). In geological time, in the course of at least two billion years, living matter has been *plastic*—there is a process of *evolution of species.* Evidently, according to laws that have not yet been elucidated (processes of mutation, in part?), a new *species* of living matter is created from time to time; in various living organisms, a new generation appears, which is morphologically and physiologically changed, and clearly different from the preceding generation. *A single, unified evolutionary process,* closely connected with the history of the planet, is observed over the course of not less than two billion years. As shown by Dana (1852), there is a process of formation, within the living matter of the biosphere, of functionally more and more powerful central nervous systems—of the brain. This process moves forward inexorably over the course of time, but with major interruptions on the order of tens, or perhaps hundreds of millions of years. Thanks to this, from the end of the Pliocene the geological role of living matter in the biosphere abruptly increases—making a jump. Thanks to human creativity, the biosphere is rapidly shifting into to a new state—*the noosphere.*

V.

Inert Natural Bodies	Living Natural Bodies
A dispersed inert natural body—solid or mesomorphic—has no special properties of motion as a single natural body. There are also no such properties in liquid or gaseous inert bodies, which consist of molecules in complex motion	There are no liquid or gaseous living natural bodies in the biosphere. The liquids and gases existing in any living body are mixed with colloidal—mesomorphic and solid—structures. *Spontaneous motion, to a large degree self-regulating, is one of the marks of any living natural body in the biosphere.*

Inert Natural Bodies	Living Natural Bodies
and which assume the form of the containers in which they are located. Gaseous bodies exert pressure on the walls of closed containers. Their motion is governed by the laws of temperature and pressure.	There are two forms of such motion for living matter. One—*passive*—occurs through reproduction, and is *a common property of all living matter.* The other—*active*—is expressed for the great majority of animals, and for a minority of plants, as the spontaneous movement of individuals and their colonies in *the medium of living matter.* The first form of motion—spreading in the biosphere, or *colonization of the biosphere*—is analogous, in the nature of its laws, to a gaseous mass, and, like such a gas, it exerts pressure, the magnitude of which depends on the rate of reproduction (the biogeochemical energy of the colonization process). The rate of colonization by living matter within the boundaries of the biosphere approaches a physical maximum—*the speed of sound in the gaseous medium of respiration.* For microscopic organisms, living in liquids, there is yet another form of motion, which matches the molecular motion of fluids, visible to us in Brownian motion.

VI.

Inert natural bodies are absolutely inert. They change as a result of external causes, being weathered in the biosphere. This bio-inert process proceeds slowly and is manifested in the course of geological time. Inert bodies do not grow and, apparently, do not increase their mass. For inert bodies, we find nothing analogous to the *growth* (and proliferation) of living organisms. To liken the growth of an organism to that of a crystal, is a misunderstanding, as becomes clear upon the first encounter with logical analysis. The atoms of an inert body do not manifest, inside it, any characteristics of motion, analogous to the biogenic migration of atoms.	Living natural bodies live, i.e. *grow and multiply.* Thanks to this, each living organism is the source and center of *a biogenic migration of atoms* from the biosphere into the organism and back again. Thereby each organism is a source of *free energy in the biosphere*—free biogeochemical energy. Biochemically, this biogenic flow of atoms creates an innumerable and continuously changing quantity of chemical molecules in living matter. Most of the chemical compounds generated in living organisms, can be synthesized by different means in the laboratory. But in the biosphere, almost all of those compounds are formed *only* in living matter. Their synthesis occurs within living matter at rates which are unheard of and not yet achievable in our laboratories. Thanks to this, biogeochemical energy appears in the biosphere, in terms of its power, as the fundamental force of change of the biosphere.

VII.

The number of inert natural bodies in the biosphere is determined by the general properties of matter and energy. It does not depend, in any explicit way, on the dimensions of the planet. The biosphere continuously absorbs and emits matter and energy from and to cosmic space. There exists a continuous matter-energy exchange of inert natural bodies. Apparently, we see here an established dynamic equilibrium—a manifestation of the same sort of organization (but not mechanism) which is characteristic of the biosphere and living matter.	The number of living natural bodies of the biosphere is quantitatively connected with the dimensions of the biosphere. The scientific working hypothesis is admissible, but requires verification, that an extraterrestrial exchange of living natural bodies occurs.

Inert Natural Bodies	Living Natural Bodies

VIII.

The size of the area occupied, and the regions in which inert natural bodies appear in the biosphere, are limited by the dimensions of the latter, and can only increase with the expansion of the biosphere.

Evidently, the biosphere expands in the course of geological time, through the motion of living matter. In this process the inert natural bodies of the biosphere play a passive role.

The mass of living matter of the biosphere is close to the limit and, evidently, remains a relatively constant value *on the scale of historical time.* It is determined, above all, by the radiant energy of the Sun, falling on the biosphere, and by the biogeochemical energy of the process of colonization of the planet.

Evidently, the mass of living matter increases in the course of geological time, and the process of the occupation of the Earth's crust by living matter has not yet been completed.

IX.

The minimum dimensions of an inert natural body of the biosphere are determined by the degree of dispersion of matter and energy—the atom, electron, neutron, etc. The maximum dimensions are determined by the dimensions of the biosphere—a bio-inert natural body. The range of sizes is enormous—10^{40} or, probably, even more.

The minimum dimensions of a living natural body are determined by *respiration,* i.e. the gaseous biogenic migration of atoms (and, in the final analysis, by the Loschmidt [Avogadro] number). These dimensions are of the order of 10^{-6} cm. The maximum dimensions have not exceeded a few hundred meters in the course of two billion years. The reasons for this have not been ascertained. The range of sizes is not large: 10^9.

X.

The chemical composition of inert natural bodies of the biosphere is a function of the composition and properties of the surrounding medium *in which they are created.* It is determined in a passive manner by the structure of the biosphere in the course of geological time.

The chemical composition of living natural bodies is created *by those bodies themselves.* Through nutrition and respiration, they select the chemical elements they need for their existence and for the creation of new living natural bodies (the autarchy of living matter). Evidently, in this process they can change the isotopic ratios (change the atomic weights of the chemical elements) in mixtures.

Thus, living organisms create the greater part of their own bodies, as independent and autonomous (within certain defined limits) bodies in the biosphere—the large bio-inert body of the planet.

XI.

The number of different chemical compounds—molecules and crystals—in inert natural bodies of the biosphere (and the Earth's crust) is *limited.* There exist a few thousands of such molecules and crystals. This determines the essentially small number of forms of inert natural bodies of the biosphere.

The number of chemical compounds—molecules and crystals—in living natural bodies is *unlimited.* It is connected with individuality, and is different for each individual unit of living matter. We already know *millions* of species of organisms and *millions of millions* of different molecules and crystal lattices, corresponding to them. Although far from all of them have been described, this character of theirs is beyond any scientific doubt.

XII.

All natural processes in the domain of natural inert bodies—with the exception of radioactivity—reduce the free energy of the biosphere (physico-chemical processes are reversible). In this way, the *free energy* of the biosphere is diminished and its *entropy* is increased.

Natural processes of living matter, as reflected in the biosphere, increase the free energy of the biosphere (i.e., decrease its entropy).

As a result of that process *the free energy of the biosphere increases,* thus showing the fundamental importance of living matter in the structure of the biosphere—and thereby the planet.

Inert Natural Bodies	Living Natural Bodies

XIII.

The chemical composition of inert natural bodies may correspond to an almost theoretically pure chemical compound, with precise stoichiometric proportions among the elements. In minerals, solid solutions predominate (isomorphic mixtures).

Free atoms of chemical elements are dispersed in all inert bodies. These penetrate all terrestrial matter, not entering into the composition of the molecules, and not always entering the nodes of the spatial lattices.

Today we know of two continuously occurring processes, causing the *dispersion of atoms:* the penetration of (cosmic) radiation, and radioactive processes, which cause a an uninterrupted dispersion of atoms—always ephemeral—in the terrestrial inert matter of the biosphere. The significance of this phenomenon is just beginning to dawn upon us. It demands theoretical and experimental study.

In the living matter of the biosphere, we always find extraordinarily complex mixtures of chemical molecules. These are always bodies of mesomorphic structure (colloidal, and more rarely crystalline, etc.). *Molecules of water,* chemically and physically bound and retaining their characteristic properties to a great extent, overwhelmingly predominate (outside the stages of the latent states of living matter). They constitute 60 to 99 percent (or possibly more) of the total weight of living matter. In latent states of living matter, the amount of these molecules ranges between 4 percent and 15 percent (possibly less).

There are no stoichiometric proportions in the gross chemical composition of living bodies. But their chemical composition is strictly determined, and more constant than the chemical composition of isomorphic mixtures in natural minerals. This composition is typical for a given *species, race etc., constituting a characteristic signature of each form of living matter.*

In this respect, there are no special biogenic chemical elements for living matter as a whole. All the elements of the biosphere are embraced by living matter. But it is characteristic, that for every chemical element its geochemistry in the biosphere involves the existence of living organisms, whose activity concentrates that element, and which are thereby distinguished from other living organisms. *Here the role of living matter is clearly of a planetary character.*

It is evident, that the elements of water—oxygen and hydrogen—dominate in the overwhelming mass of living matter. Besides them, the dominant elements in protoplasm (C, N, P, S, K, Na, Cl, Ca, Fe, Si, Mg, etc.) must be characteristic of all organisms. The elements in skeletal structures, perhaps, play an even more important role in the biosphere in general: Fe, Ca, Mg, P, S, N, C, H, O, Mn, Si.

The number of chemical elements *necessary* for each species of matter, for its prolonged, normal life, is rapidly increasing as it is studied, and has now reached a total of 60 most studied ones. Without them, normal, prolonged existence is impossible. Dispersed elements (chiefly the so-called trace elements) often play a primary role. It is conceivable, that the number of elements in each living organism exceeds 80.

The phenomena of dispersion of chemical elements appear here, as they do in inert natural bodies. This process evidently is not limited to the planet's matter.

XIV.

With the exception of radioactive decay, isotopic composition (for the terrestrial chemical elements) does not change in inert natural bodies of the *biosphere.*

Evidently, there exist natural processes *outside the limits of the biosphere*—for example, the movement of gases under high pressures and at high temperature in the Earth's crust—which can shift the isotopic ratios.

These shifts do not violate the basic constancy,

Evidently, a shift (within certain ranges) in the isotopic composition (atomic weights) inside living organisms is *a characteristic property of living matter.* This has been proven for hydrogen, carbon, and potassium, and is probable for oxygen and nitrogen. This phenomenon calls for precise investigation.

It is becoming more than probable, that a chemical element, upon entering a living organism, changes its isotopic composition.

Since this process must be connected with an expenditure of energy, we should expect to observe, in the biogenic migration of

Inert Natural Bodies	Living Natural Bodies
in first approximation, of atomic weights, since those meteorites (galactic matter) which have been studied give the same atomic weights, with accuracy to the second decimal place. One of the most important tasks of geochemistry at the moment is to obtain a more precise definition of the atomic weight of chemical elements in inert bodies, than is possible through chemistry.	chemical elements, which links together the living and inert matter in the biosphere, a considerable delay in the exit of these elements from the cycles of biogenic migration. This phenomenon was noted by K.M. von Baer for nitrogen a long time ago. It is possible, that it is a general phenomenon.

XV.

The overwhelming majority of solid and mesomorphic natural bodies of the biosphere are characterized by their stability in the course of geological time—more than two billion years. This explains the small number of types of such bodies. W. Bragg correctly pointed out, that among crystalline structures (and, obviously, molecules) of the Cosmos, only the most stable and firm have persisted over the course of time. It seems to me, that we can see in this fact the result of an extremely long-term state of the Cosmos, which we are studying. The study of the radioactivity of crust rocks shows, that the atoms of the basic material of the lithosphere *have not moved from their relative positions in the course of hundreds of millions, up to two billion years,* while remaining the whole time in motion.	The picture changes totally when we look at the living bodies of the biosphere. A huge majority of these change in form through the process of evolution, and transform into other species or races of living matter. *This is a manifestation of time, in the living matter of the biosphere.* This phenomenon is rather more complex than we imagine it to be in our understanding of evolution, since the evolutionary process has not yet been expressed in quantitative terms and its rate of change has not been quantitatively estimated (which is now possible). Despite the plasticity of living matter, there are cases of some organisms that are completely fixed. The organism does not change its morphological-physiological structure, remaining in the contemporary biosphere a living witness of the biosphere's past. Here we are talking about hundreds of millions of years (for Radiolaria from the Algonkian era and Lingulae from the Cambrian period—more than two billion years). Unfortunately, this *phenomenon of morphological constancy*—these persistent life forms—has not yet been studied by biologists. Evidently, a continuous migration of atoms occurs inside living bodies, sharply contrasting with their immobility inside inert atomic structures over the course of time. The method of [radioactively] tagged atoms is beginning to reveal to us a new process of continuous biogenic substitution within the molecules, in which atoms of one and the same kind are exchanged—*an uninterrupted intramolecular biogenic flow of atoms.*

XVI.

All physico-chemical processes in inert natural bodies are reversible in time. The space, in which they occur—the space of Euclidean geometry—is in an isotropic or anisotropic crystalline state.	The physico-chemical processes, which create living natural bodies in the biosphere, are irreversible in time. It is possible, that this will turn out to be a consequence of a special state of space-time, having a substrate that corresponds to a non-Euclidean geometry. At the moment, this may be put forward as a scientific working hypothesis, to be verified. From this hypothesis the possibility follows logically, that there exist, *in our reality, phenomena of the transition of geometrically different states of space, one into another. The existence of the living matter of the Earth's biosphere is one such manifestation.*

III. Supplementary Explanations

The admissibility of the conception of different states of space-time existing simultaneously in the biosphere. **Its geometrical heterogeneity.** *In the biosphere, time should be studied in the same way as matter and energy. The working hypothesis of a special geometrical state of the living matter of the biosphere, corresponding to one of the Riemannian geometries.*

16 Analyzing the above Table (Section 15), we see that the distinctions between living and inert bodies in the biosphere can be reduced to three basic parameters: (1) differences in energetic characteristics, (2) differences in chemical characteristics, and (3) differences in space-time characteristics.

It seems to me, that the first parameters do not require any special interpretation from the standpoint of scientific work. When the point of departure for the explanation of Nature was Man, it was inevitable that Man be taken as the standard of comparison, leading to acceptance of the primacy of philosophy over science. In this connection, people thought they saw in living natural bodies the manifestation of a special *vital force* (this came from pondering mental processes), which sharply and definitively distinguished living from dead. I leave aside the even earlier, animistic views. All of these conceptions, both new and old, have departed, or are departing, from the domain of modern science into the past.

The latest vitalist conceptions are based not on scientific data—which serve, rather, to illustrate them—but on philosophical notions (Driesch's entelechy, for example, and so forth). The notion of a special vital energy (W. Ostwald) is likewise more connected with philosophical, than with scientific data. Facts have failed to confirm its actual existence.

The provenance of the energy of living matter (Section 7) is beyond any doubt. It is completely confirmed by quantitative, experimental calculations.

17 Likewise, there is no need to discuss chemical composition. There are no special, life-bearing, biogenic chemical elements, as was still thought quite recently (Section 15, XIV).

The possibility is not excluded, incidentally, that chemical elements may have a different atomic weight, but then analogous changes should occur also in inert natural bodies outside the biosphere (and, perhaps, sometimes within it?). All of these phenomena require systematic scientific study.

Beyond a doubt, the overwhelming majority of biochemically formed molecules sharply differ, from the chemical compounds of inert natural bodies. In the latter, such molecules do not form. Thanks to biogenic migration, however, they do form in the geochemical cycles of the biosphere, where atoms freely move from living bodies to inert ones, and back again. The reaction takes place by utilization of the same energy.

The possibility must be considered, of delays in the biogenic migration of chemical elements, in the event their atomic weight changes (Section 15, XIV). This will be decided by experiment and observation in the near future.

18 But, for space-time, matters are more complex. On the one hand, we enter here into a domain that has not yet been investigated scientifically; and, on the other, we address that substrate of all natural processes (their geometry), which the naturalist is accustomed to leaving aside, unexamined, in his scientific work.

This substrate—the geometrical state of physical space—lies deeper than all physico-chemical processes. But, I think, it is even more real than they are.

At present, the reigning notion—sometimes wrongly posited as an axiom—is that one and the same geometry is manifested in all terrestrial phenomena. But the naturalist cannot construct his conceptions on the basis of axioms, not even logical axioms, because their axiomatic character cannot be demonstrated except by scientific experiment, experience, and observation. Logic is always less comprehensive than Nature (the biosphere, in this case), since logic corresponds to an abstraction, i.e. a simplified picture of Nature.

In considering the *possibility* of the simultaneous occurrence of different geometries on our planet, we must verify their existence experimentally. If the naturalist comes upon phenomena, which permit him to check this by experiment and observation, he is obliged to do so.

Before our present century, only three-dimensional Euclidean geometry was considered in scientifically studied phenomena. In the new scientific-philosophical conceptions, connected with Einstein's constructions, four-dimensional space is considered; this space corresponds, in the opinion of some, to a Riemannian, rather than a Euclidean space. Theoretical physics is rightly searching for new pathways here, but it has not carried its analysis through to the end, as logic demands.

19 Before going further, it is indispensable to clarify, to what extent it is possible, in our scientific reality, to admit the simultaneous manifestation of *spaces, characterized by different geometries,* in different domains.

It seems to me, that people today assume that such a thing is impossible, without submitting the question to analysis. We can see this from the history of geometry. In his time, Lobachevsky allowed the possibility, that the structure of the space of scientific reality was defined by a new geometry, which he had discovered, rather than by Euclidean geometry. He tried to arrive at an experimental test of this conclusion, by taking a real measurement of the largest star triangles in the heavens. At the present time, Eddington is trying to detect a true four-dimensional space—one of the Riemannian spaces—corresponding to Einstein's conception of the Cosmos.

But all of this is only the simplest, most abstract conception of the Cosmos, which might satisfy the geometer and the theoretical physicist, but which contradicts the entire empirical knowledge of the naturalist.

Another conception is logically possible—the conception of *the geometrical inhomogeneity of reality.* It is closer to precise empirical knowledge, without contradicting what we know scientifically: *It is the supposition, that, in different cases and different manifestations of the Cosmos, different geometries may be manifested in phenomena under scientific study.*

The hypothesis of a single unified geometry for the Cosmos as a whole, for the entirety of reality, is inseparably connected with the hypothesis, that the propositions of geometry originate as special properties of our reason. The history of geometry refutes this.

20 This leads me to the following considerations. We know now, that there can be a whole array of geometries, and that they may be divided into three types—Euclidean, Lobachevskian, and Riemannian—,and that all of them are irreproachable and equally true. At present, the work of generalization is proceeding successfully, to bring them all into *a single generalized geometry.*

But at the present moment, the history of science clearly demonstrates that geometry and its laws, with respect to their fundamental basis, are adduced in empirical fashion, like all other scientific generalizations of the properties of matter and energy. The foundation, from which these laws are derived in deductive fashion, is the precise scientific observation and experience of the thinker. In science today, one can hardly proceed from other philosophical and unscientific notions about the genesis of the laws of geometry, as a starting point, and then see in them a logical manifestation of human reason. I always prefer, wherever it is scientifically permissible, not to depart from an empirical scientific basis.

Starting from such a basis, one can, if necessary, allow that reality is geometrically inhomogeneous, that different geometries may be manifested in different phenomena, and that we must take this into account in our scientific work. *In the biosphere we confront this sort of geometrical heterogeneity.*

21 For us, space is inseparable from time. This conception is not a consequence of the theoretical propositions of Einstein, but was obtained independently of them and much earlier. I have tried to show this in another location.

We are presently living through an extremely important epoch in the development of science. For the first time, the object of scientific investigation is *time,* which for centuries remained outside its scope. This circumstance characterizes the science of our time and distinguishes it from the science of the 19th century. It is now becoming clear, that time is an extremely complex manifestation of reality, and that the content of this concept is extremely rich.

Speaking about space-time, we merely indicate the inseparability of one from the other. *For science there is no space without energy and matter, nor, in exactly the same sense, without time.* The conception of Minkowski and his predecessors, about time as a fourth dimension of space, is a mathematical abstraction having no logical grounding in scientific reality; it is a fiction, which does not correspond to the real content of science, nor to a true scientific conception of time. Time is not a dimension of metric geometry. Of course, time can be expressed in geometry by a vector, but it is obvious that such a representation of time does not subsume all of its properties in the natural phenomena studied by the naturalist; it provides him nothing real by way of knowledge. He has no use for it.

Twentieth-century science is now at a stage, when *the moment has arrived to study time, in the same way as we study the energy and matter filling space.* Minkowski's time, considered as the fourth dimension of Euclidean space, does not correspond to the time, which is actually observed in physical space. We should not forget, that in concrete scientific work, we, generally speaking, are not dealing with the abstract absolute space of geometry. At every step, we are dealing with the much more complex *real space of Nature.*

In a vacuum and very often in gaseous media we can extremely often, without need of corrections, use all the conclusions that follow from the properties of the abstract space of Euclidean geometry. But, not always. Already in most of the problems we face, involving fluids and solid bodies, we cannot do this. In connection with this, it is convenient, as we shall see, to distinguish the real space of Nature—in this case the biosphere—as *a physical space,* from geometrical space; in the manner, that Helmholtz apparently, first proposed to do.

In exactly the same way, the naturalist's *time* is not the geometrical time of Minkowski, is not the time of mechanics and theoretical physics, or chemistry, and is not the time of Galileo or Newton.

In Section 15, I indicated the sharp empirical distinction of time for living and inert natural bodies of the biosphere. In living natural bodies it is manifested in the *succession of generations*—a phenomenon, which is absolutely absent in inert bodies.

The succession of generations is the characteristic biological manifestation of time, sharply distinguishing one form of living matter from another, with different scales of comparison for each. It is also possible to find a common scale for all of these.

22 Proceeding from everything said above, it is convenient for purposes of organizing scientific work, to take as a scientific working hypothesis, that the space inside a living organism is different from the space inside inert natural bodies of the biosphere; that this space does not correspond to a special state of living matter within the bounds of Euclidean geometry, and that time is expressed in this space by a polar vector. The existence of right- and left-handedness, and their physico-chemical non-equiva-


NASA
Vernadsky's concept of the noosphere envisioned the extension of the human mind over the Earth and into space. Here, Astronaut Bruce McCandless walks in space, during a Shuttle mission.

lence, point to a different geometry than Euclidean—the geometry of space inside living matter.

From my discussions with geometers, it has become clear to me that the geometry, corresponding to the required conditions, has not yet been elaborated. According to indications by Academician N.N. Luzin and Professor S. P. Finikov, it is possible, that it is one of the geometries of the Riemannian type; perhaps one of those pointed to, but not elaborated, by Cartan. This geometry reduces all space to a point, endowed with the germ of a vector.

It were desirable, that these questions attract the attention of geometers. The investigative work of naturalists, in reality, always employs the mathematical constructions of geometers. Without them, it cannot develop correctly. On the other hand, mathematical thinking grows and discovers its new domains, when scientific thought or the life around us confronts it with new problems. *The geometrical character of the space, occupied by the living matter of the biosphere,* is such a new problem. Characteristic for that space are polar vectors (i.e. the absence both of a center of symmetry and of complex symmetry); the non-equivalence of right- and left-handedness (their failure to appear in combination or appearance in only partial combination); the marked chemical non-identity of right- and left-handed phenomena and compounds, and atomic structures (molecules and monocrystals). Characteristic is the conspicuous absence, in living organisms, of plane surfaces and straight lines; the symmetry of living organisms is distinguished by the curved lines and curved surfaces, characteristic of Riemannian geometries. One more identifying mark, which is usual for Riemannian geometries, is a finite and closed space, sharply distinguished from its surroundings, and autonomous. This is completely coherent with the character of aloofness of living organisms in the biosphere, their autarchy.

Which of the array of Riemannian geometries is appropriate here? What are its geometrical characteristics? It seems to me, that this task cannot be ignored by our geometers. It deserves their attention in and of itself as a geometrical problem.

All the more so, because it is connected with a still more general physical problem: with the question of the geometrical states of *physical space,* which have been very little touched upon by philosophical and physical thought.

In the next article I shall try to present a concept of this problem.

I consider it a pleasant duty to express my gratitude to N.N. Luzin and S.P. Finikov, who helped me with valuable suggestions in the course of our conversations.

—Uzkoye, June 1938

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8. I have to introduce a *new word* for this old concept, although the enormous significance of the concept it embraces is clear to everyone, as is the exclusive importance of work on the scientific apparatus, in terms of both the time and the labor, spent on it by scientific researchers. This is a consequence of vestiges of the past, of a time when work in philosophy—rightly so, at that time—was considered more fundamental than scientific work.
9. Samoilov, Ia. *Biolity [Bioliths].* Moscow, 1929.
10. On Redi's principle, see Vernadskii, V. *Ocherki geokhimii [Sketches on Geochemistry],* 4th ed., Leningrad, 1934, p. 209.
11. For viruses, it is still unclear whether we are dealing with a new form of organism ("living protein"), or with a protein, which contains the spores of miniscule organisms. It is thought that *the proteins cannot be cleansed of these spores by crystallization.*
12. Vernadskii, V. *Problemy biogeokhimii [Problems of Biogeochemistry].* Leningrad, 1935. Vol. 1., 8 f.

Vladimir Ivanovich Vernadsky (1863-1945)

Pioneer Of the Biosphere

by George B. Kauffman

A brief biography

Courtesy of the History of Geology Department, Vernadsky State Geological Museum, Russian Academy of Sciences

Vernadsky with his wife, Natalia Yegorovna Vernadskaya, in 1911

Vladimir Ivanovich Vernadsky, the Ukrainian-Russian geochemist, mineralogist, biogeochemist, crystallographer, naturalist, philosopher, and foremost proponent of the concept of the *biosphere,* was born in St. Petersburg on Feb. 28, 1863, into a noble family from Ukraine. He died in Moscow in 1945.

His father, Ivan Vasilyevich Vernadsky, had pursued graduate studies in Western Europe and was an outstanding member of the liberal, mid-19th century intelligentsia. A master of several European languages, he was a professor of political economy at Kiev and Moscow universities, and later at the Main Pedagogical Institute and the Aleksandrov Lycée in St. Petersburg. An opponent of serfdom, and an active advocate of constitutional democracy in Russia, he espoused liberal causes in *The Economic Index* (*Ekonomichesky ukazatel*) a weekly journal that he edited from 1857 until 1864, when he abandoned it because of censorship problems.

In 1862, Ivan married his second wife, Vladimir's mother. Anna Petrovna Konstantinovich came from a Ukrainian military and land-owning family, and was a music teacher who had sung in the famous choir of composer Mili Balakirev.

Education

Young Vladimir, a precocious but reticent child, read avidly about Ukrainian history and culture, and taught himself Ukrainian and Polish. A veritable polyglot, he was later to become proficient in 15 languages.

In the fall of 1881, he entered St. Petersburg University. For some time, he vacillated between the History-Philology and the Mathematics-Natural Science faculties, but, influenced by the chemists Dmitri Ivanovich Mendeleyev (1834-1907) and Aleksandr Mikhailovich Butlerov (1828-1886), and, especially, by the mineralogist Vasili Vasilyevich Dokuchayev (1846-1903), he decided on a scientific career in crystallography and mineralogy.

Dokuchayev, who directed young Vernadsky's first independent research, viewed soil as a partly inorganic, partly organic material, that develops slowly, by the interaction of plants, animals, rocks, and climate. He viewed nature as a complex, interacting whole—a viewpoint that reinforced

Vernadsky's holistic approach, in which natural phenomena change "historically" with time.

Vernadsky graduated in 1885. His undergraduate thesis, "On the Physical Properties of Isomorphous Mixtures," in which he showed the ability of a series of elements to replace one another in minerals, was so well received that he was asked to continue his studies to prepare for a teaching career. In 1886, he became curator of the university's mineralogical collection, and that fall, he married Natalia Yegorovna Staritskaya, a serious plain woman three years his senior, who was fluent in French and German and later translated some of his articles. Their marriage lasted 56 years, until Natalia's death in 1942. The couple had two children, both of whom emigrated to the United States—Giorgi, later anglicized to George (born in 1887), a distinguished historian of Russia at Yale University, and Nina (born in 1898), a psychiatrist.

Courtesy of the History of Geology Department, Vernadsky State Geological Museum, Russian Academy of Sciences

Vernadsky with his daughter Nina Vladimirovna Tol, taken in Paris in 1930.

From 1888 to 1890, Vernadsky travelled extensively. He worked and studied in Munich under crystallographer Paul Heinrich von Groth (1843-1927); in Paris, under chemist Henri Louis Le Châtelier (1850-1936), and geologist Ferdinand André Fouqué (1828-1904); as well as in England, Switzerland, Austria, and Italy. He became a passionate promoter of close scientific contacts with other countries, and frequently travelled abroad, until prevented by the Soviet government in the mid-1930s.

Crystallography and Mineralogy

In the fall of 1890, Vernadsky was appointed a *Privat-Dozent* (unsalaried lecturer) in mineralogy and crystallography at Moscow University. In 1891, he defended his master's thesis, *O gruppe sillimanita i roli glinozema v silikatakh* (On the Sillimanite Group and the Role of Alumina in Silicates). Here, he experimentally disproved the previously held view that aluminosilicates, the most abundant minerals in the Earth's crust, were salts of silicic acid, and that their acidic properties could be attributed to alumina (aluminum oxide) alone. Instead, with his brilliant intuition, he proposed a new structure for these minerals, in which aluminum is chemically similar to silicon. He argued that the kaolin nucleus ($Al_2Si_2O_7$) is shared by all the minerals in this family. This theory, which Le Châtelier later called "a brilliant hypothesis," postulated that silicon and aluminum in aluminosilicates are linked by oxygen atoms situated at the vertices of tetrahedra, the cavities of which are filled with large cations. This structure was not confirmed experimentally—by X-ray diffraction studies—until the 1930s.

The silicate minerals, which constitute 90 percent of the Earth's outer crust, are all built on the fundamental unit of the SiO_4 tetrahedron (a silicon atom surrounded by four oxygen atoms). Vernadsky's Masters thesis was a revolutionary breakthrough in the understanding of the aluminosilicates.

The first quarter-century of Vernadsky's scientific career was devoted largely to crystallography and mineralogy. One of his great contributions to mineralogy was his work on the paragenesis of minerals, that is, their origin, and how the presence of one mineral affects the formation of another. Previously, mineralogists were primarily concerned with the description of minerals, rather than their history. In 1897, Vernadsky was awarded the doctorate for his dissertation, *On the Phenomenon of Gliding in Crystalline Substances.* (Gliding is the movement of one atomic plane over another in a crystal.)

Multifaceted Activities

In 1898, Vernadsky was appointed a Professor at Moscow University. Although he remained active as a scientist, even during the 1905 Revolution, like his father before him, he increasingly became politically active. He became a national political figure, and was elected to the State Council, the upper house of the new Russian parliament, where he served from 1906 to 1911, when, as a protest against the government's reactionary and undemocratic treatment of the university, he resigned, along with 28 percent of the faculty.

He moved to St. Petersburg, where the St. Petersburg Academy of Sciences elected him an Associate Member and Academician, in 1909 and 1912, respectively. In 1914, he became director of the Academy's Geological and Mineralogical Museum.

World War I brought unprecedented demands on the

Russian economy, and in 1915, Vernadsky was appointed to the Commission for the Study of the Natural Productive Forces of Russia, of which he was president in 1915-1917 and 1926-1930. In 1916, Vernadsky became chairman of the Scientific Council to the Crop Farming Ministry, while being simultaneously involved in research on mineralogy, geochemistry, natural resources, the history of science, science management, and meteorites.

Although opposed to Bolshevism, and despite an academic offer from England, Vernadsky remained in Russia after the revolution and contributed greatly to the new government's industrialization efforts. In 1919, he established the first academy of natural sciences in the USSR, the Ukrainian Academy of Sciences, of which he was the first president.

Employing his great organizational and managerial talents, Vernadsky founded no less than 20 academic institutes. For example, in 1922, he founded the Radium Institute in Moscow and was its director from 1926 to 1938. In 1926, he founded and became chairman of the Commission on the History of Knowledge, which provided a nucleus for the present Institute for the History of Science and Technology of the Russian Academy of Sciences. In 1927, he founded and became head of the academy's Section on Living Substances, now the V.I. Vernadsky Institute of Geochemistry and Analytical Chemistry. He also proposed a polar commission to study the 40 percent of Russia that is covered with permafrost. In 1928, he organized and became director of the Biogeochemical Laboratory of the USSR Academy of Sciences, devoted to the new interdisciplinary science, biogeochemistry, which he founded. Since the time of Mikhail Vasilyevich Lomonosov (1711-1765), no one had contributed so much to the organization of Russian science.

From 1921 to 1925, Vernadsky resided in Paris, where he worked with Marie Curie (1867-1934) and taught geochemistry at the Sorbonne; his lectures were published in French. He was one of the first to recognize radioactivity as a powerful, untapped source of energy, and he laid the foundations of the new science of radiogeology. During this period, he also travelled, mainly in France, and carried out research on geochemistry, mineralogy, crystallography, biochemistry, marine chemistry, the evolution of life, and futurology.

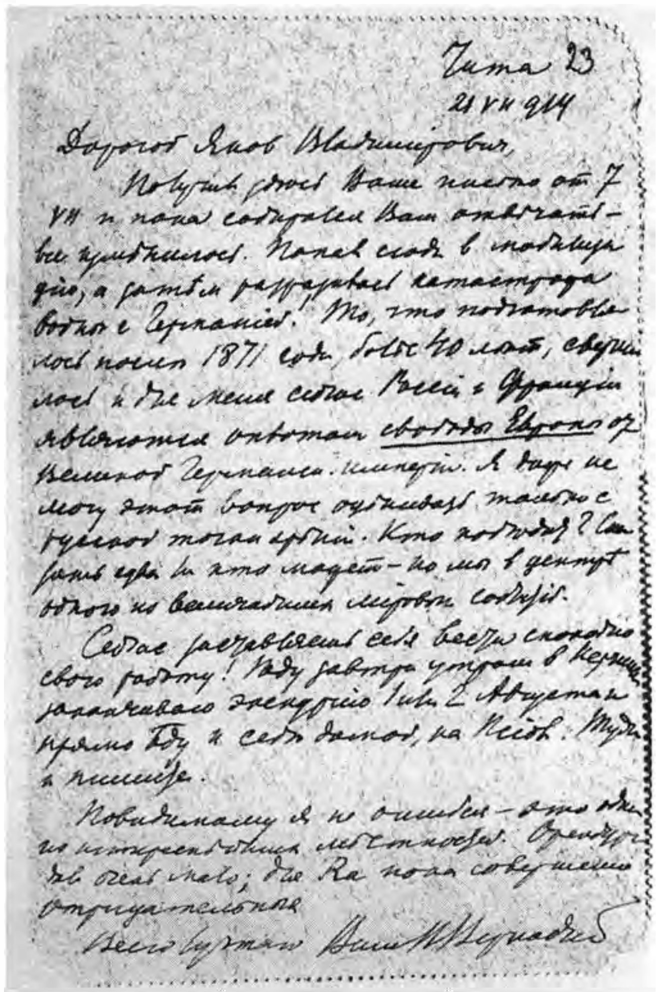
His Last Years

Although after his return from abroad, Vernadsky abandoned the organized political activity of his earlier years, he nevertheless rejected Marxism-Leninism publicly and provided refuge in his laboratory for the children of persons who were persecuted for their social origins or political or philosophical views. He even provided them with money, letters of recommendation, or petitions to the government. Yet, unlike other scientists who suffered during the purges, his great prestige and longstanding patriotism prevented his arrest or public campaigns against him.

The aging Vernadsky retained his unquenchable thirst for knowledge. In his later years, he wrote articles on natural waters, cycles of substances and gases of the Earth, cosmic dust, geothermy, the problem of time and symmetry in science, the problem of right and left in nature, the isotopic composition of water in minerals and rocks, and the geological envelopes of the Earth.

Vernadsky made his last appearance before an international geological congress in 1937, when he presented a paper, "On the Significance of Radioactivity for Modern Geology," and proposed the formation of an international commission for geological data. In 1940, he proposed the creation of a Uranium Commission within the Academy of Sciences, and during World War II, he lobbied for a crash atomic energy program, which led to the Soviet Union's later transformation into an atomic superpower. Although not neglecting the pressing need of nuclear power for military purposes, he recognized and emphasized its long-range peaceful applications. A scientific internationalist, during the war he advocated close ties with England, and particularly with the United States during the postwar period.

George B. Kauffman, Professor of Chemistry at California State University, Fresno, since 1956, is the author of 17 books and more than 1,650 articles.



Courtesy of the History of Geology Department, Vernadsky State Geological Museum, Russian Academy of Sciences

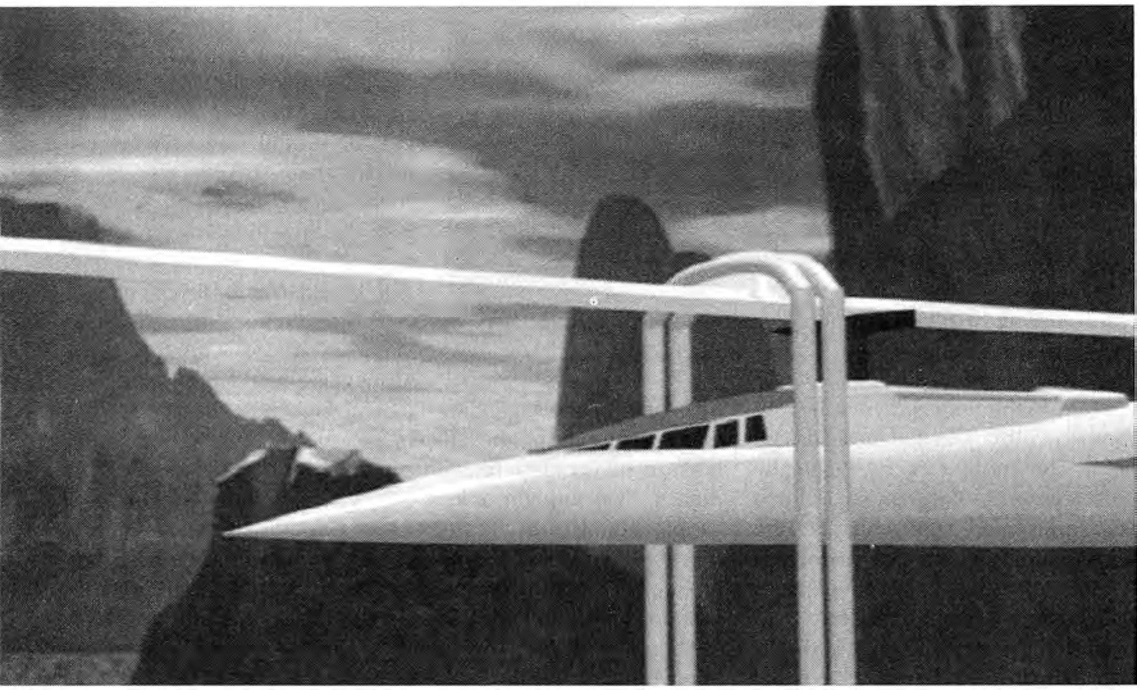
A letter written by Vernadsky in July 1914, to Yakov Vladimirovich Samoilov, his favorite student, which reveals Vernadsky's views of World War I.

A 600-mph Railroad Suspended by Magnets

by Laurence Hecht

Magnetrain, a patented magnetic levitation system for high-speed rail, promises an efficient passenger and freight-handling system to develop the world, link continents, and solve urban traffic congestion.

Rail is by far the cheapest mode of land transportation. Measured in dollars per ton-mile of goods carried, conventional rail freight is approximately ten times cheaper than trucking. Until the 1950s, most of the long-distance freight carried overland in the U.S.A. travelled by rail. Trucks were used primarily for local delivery, short hauling, and certain specialty items. Rail is also the most efficient means of carrying passengers in high-density urban areas.[1]

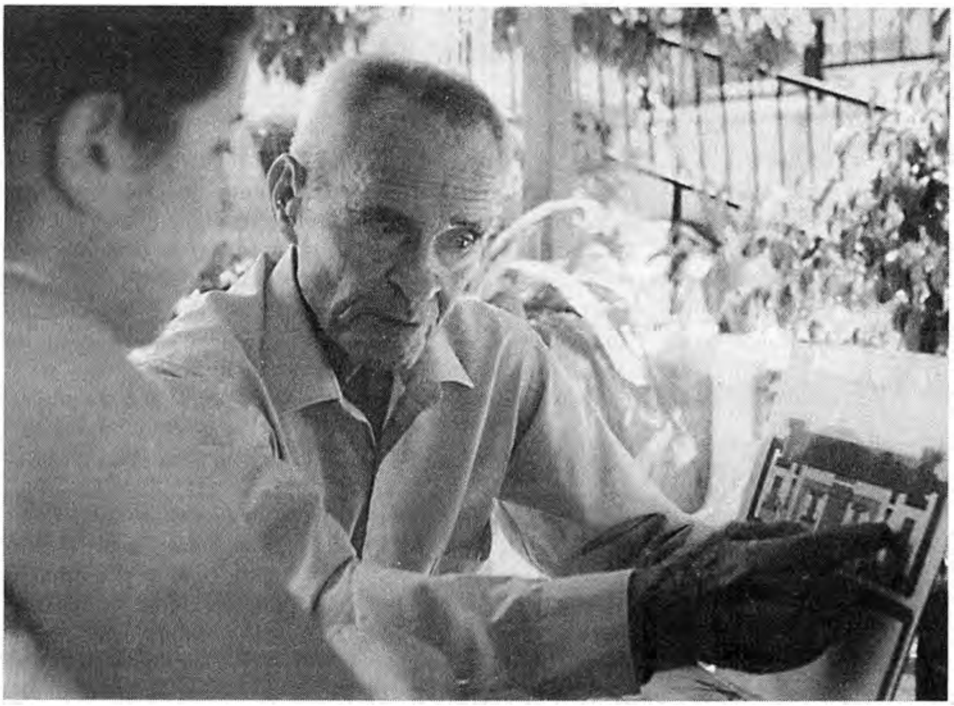


Courtesy of Magnetrain

Artist's conception of the Magnetrain as it enters a station.

It would seem obvious that the reconstruction of freight and passenger rail capabilities in the industrialized nations, and their first-time construction in the nations of the developing world, be a priority of any government wishing to serve the general welfare. Yet, it is unlikely that the rail systems of the 21st century will operate on the same principles as those we associate with railroads of the past. The steel-wheel-on-steel-rail design has served us admirably for more than 170 years. Railroads of the future will more likely use a friction-free design, employing the attractive or repulsive force of a magnet to suspend the train either above or below its track. In such systems, called magnetic levitation, the friction and noise associated with conventional, steel-wheel-on-steel-rail systems are eliminated, and much higher operating speeds and lower track-maintenance costs can thus be achieved.

There are many ways to achieve magnetic levitation. Two systems of magnetically levitated trains have been brought to the large-scale demonstration stage as of this date: one in Emsland, Germany, where a train routinely achieves speeds of more than 400 km/hour on a 31.5-km demonstration track, and one in Japan. The German system uses electromagnets, mounted on a flange protruding inboard from the lower part of



Laurence Hecht

Colonel Vinson explains the working of his hydraulic control system to Anna Shavin, a collaborator of 21st Century.

the train car, which are attracted to the underside of a large I-beam shaped rail (see photo, p. 48). The Japanese design employs a repulsive system. The motion of cryogenically cooled superconducting coils, carried in the train car, induce a repulsive field in the specially designed track, which lifts the train as it travels. In the United States, a number of other types of magnetic levitation systems have received government funding, and small test tracks have been built for them.

All of the systems so far funded use *electromagnets* (that is coils of wire wrapped around an iron core, which behave like magnets when electricity is passed through), to suspend, or levitate, the train. A *permanent magnet* is the term for a piece of iron or steel alloy that retains its magnetism without the need for an external electrical current. Although the use of permanent magnets for levitation had at times been contemplated, no designs have been brought to completion.

What Is Magnetrain?

Magnetrain is the name for a maglev train system using a *permanent magnet* levitation system. It was first conceived by the American inventor, Colonel (ret.) Roy D. Vinson, in 1972. At that time, the idea of high-speed rail transport using magnetic levitation was in the air. The Apollo Program, in which Colonel Vinson had played a part, had just taken man to the Moon. To move us across the Earth at speeds approaching the speed of sound, silently suspended from rails by a magnetic air gap, did not seem so far-fetched an idea. In fact, a system developed by two physicists at the Brookhaven National Laboratory in 1964, proposed using super-cooled, superconducting coils to achieve the magnetic levitation. (This was the system which the Japanese government was to adopt about a decade later.)

Colonel Vinson was only vaguely aware of the idea of magnetic levitation at the time. He had no detailed knowledge of any of the systems then being contemplated. Driving down the Los Angeles freeway with an engineer friend one day, it occurred to him that a permanent magnet of sufficient strength might provide an ideal way to levitate a train car. "But how would you keep the magnet from grabbing on to the track?" his friend asked him. He didn't know the answer, but the problem had gotten hold of him. A short time later, finding himself a casualty of the massive wave of layoffs then striking the aerospace sector, he found himself with the time to attack the problem.

In World War II, Vinson, a regular Army officer, served as a Major in armor with the 15th Army of General Gerow, and the 3rd Army of the legendary General George S. Patton, Jr. He was known among the officers and men as "George Jr.," not because of any close relationship to Patton, but because, as he puts it, "we thought alike." Vinson describes himself as an "annihilationist," in the tradition of General Ulysses S. Grant. It is the theory that the purpose of warfare is to destroy the enemy's warfighting capability as fast as possible, to the end of bringing about an end to the war, by unconditional surrender, as soon as possible. This theory of warfare suited his personal temperament, Vinson says. Whenever he confronted a problem, whether personal, intellectual, or military, he attacked it with all the forces at this command, until he had conquered.

Such was his approach to the challenge of levitating a train car using permanent magnets. After many false starts, of which he says "I will never reveal them, because they are so foolish," he came to the solution. The train would be suspended by the force of permanent magnets from two parallel steel rails suspended from towers above the ground. To solve the problem of preventing the magnets from grabbing onto the rail, he would use sets of, not one, but two magnets. The principal magnets, holding up the weight of the car, would be attracted to the rail above. But a second magnet, of lesser strength, would act in repulsive mode to create a small air gap between the principal magnet and the rail. A pair of these sets of magnets would be contained within a levitation compartment above the train. Perhaps six or eight such pairs would be positioned above each train car.

The reader can get a feel for the essential idea behind this new levitation system by holding a strong magnet under a fixed steel object. The magnet will try to attach itself to the steel. Now, with the other hand, push the hand holding the

Magnetism expert Klaus Kronenberg (l.), a supporter of the Magnetrain concept, with 21st Century *editor Laurence Hecht.*

magnet, away from the steel object. It will be seen that there is a small air gap in which the magnet is neither fixed to the steel, nor free to move away from it. It is a *region of attraction.*

The second problem was to find a means of maintaining and adjusting that air gap as the train car underwent changes in weight, as a result of loading and unloading, or from aerodynamic stresses. This, Colonel Vinson solved, by using a system that had become familiar to him from experience in the automotive and aerospace industries—hydraulics. The attractive and repulsive magnets would be mounted on pistons, themselves contained in oil-filled cylinders. The oil in these two cylinders would be in communication with a third cylinder, the *weighing cylinder.* The cargo or passenger compartment of the train would be suspended from structures, in the shape of inverted-U's, attached to a pair of pistons which would press down on the weighing cylinder like a shock absorber in a car.

Colonel Vinson's Magnetrain concept refers to the unique levitation system and the earthquake-resistant steel towers which suspend the train above grade. The propulsion of the train would be accomplished by the same means applied to existing maglev systems—that is either linear induction or linear synchronous motors. These motors are a variation of the familiar electric motor, in which a varying magnetism in the stationary (or field) coils causes continuous rotational motion of a rotor. In the linear motor variation, the stator, or field, coil is effectively stretched out over the length of the train track. A varying electrical current is supplied to the track or guideway ahead of the train's path, in such a way that the induced magnetism results in a continuous forward motion.

How Magnetrain Works

Figure 1 is an overview of the towers and overhead track structure from which the train cars would hang. Clearance

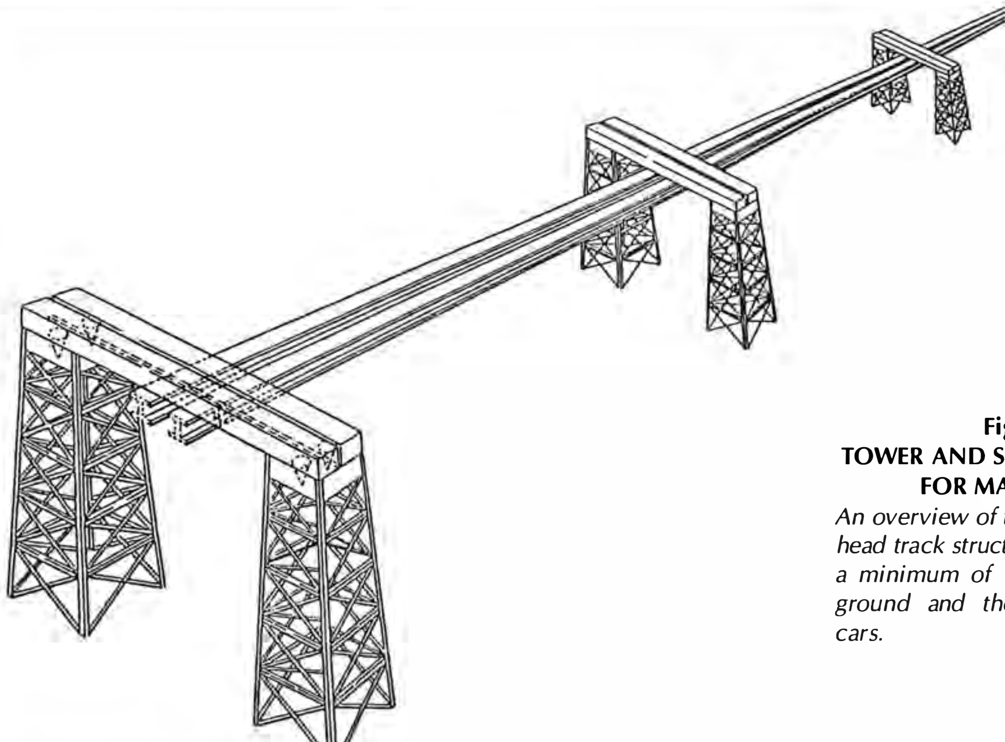
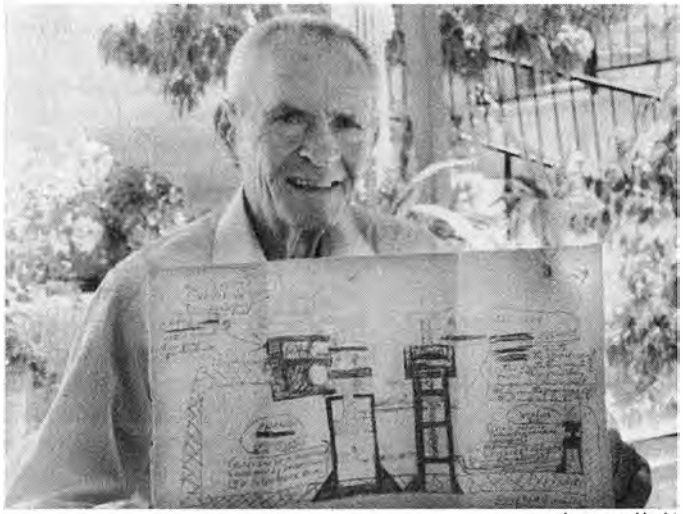


Figure 1
TOWER AND SUSPENDED TRACK FOR MAGNETRAIN
An overview of the towers and overhead track structure. There would be a minimum of 18 feet between the ground and the underside of the cars.

How Magnetrain Was Invented

21st Century editor Laurence Hecht asked Col. Roy D. Vinson how he came upon the design of Magnetrain. This is the answer the Colonel gave, in an interview conducted Aug. 23, 2000, at the inventor's home near Covina, Calif.



Laurence Hecht

Colonel Roy D. Vinson on the patio of his home near Covina, California, shows off the original 1972 sketches on brown paper bag which were the kernel of the Magnetrain invention.

Well, I had been fired from my last job in industry where I had been brought into this corporation to set up an engineering control system on two huge shipbuilding contracts for the United States Navy—an aircraft carrier and its destroyers. I had a severe difference of opinion with the director, so at the first opportunity, when they, let us say, reduced the forces, I was in the group—which I expected. At any rate, having been fired from this job, and not having another one in mind, or any desire to seek another one, because I felt I had had enough of industry, I set about something to keep my mind occupied, something I hoped would be useful.

So, one day I was driving down to San Diego with a good friend of mine, Theodore Anvick, a well known engineer, a design engineer of great ability, and also greatly appreciated throughout the world, and I remarked to Ted— I don't know how I came to think of it, I said, "You know, Ted, if we could get a permanent magnet that was strong enough, light enough in weight, and small enough in volume, and cheap enough to produce, it occurs to me that it would be an ideal way to lift a train and the cars of a train."

And then Ted said, "Yes, that sounds good, but how are you going to control it and keep it from grabbing the steel? How are you going to make arrangements for a difference in weight between the cars, or within any one car? How about wind gusts?"

I said, "Well Ted, I just mentioned this, *if* we could do all these things."

"Yes," he said, "Roy there's a lotta' *ifs.*"

"I'll grant you that," I answered, "but it just occurred to me, it would be very good if we could overcome it."

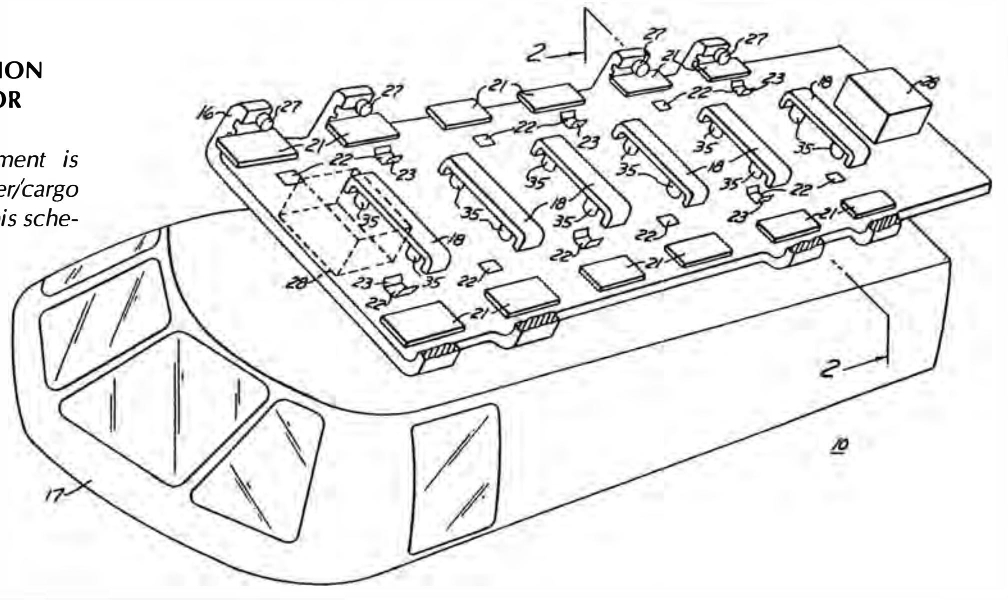
So, this intrigued me—and finally, very shortly thereafter, I decided I'd have a go at it, because I had nothing else really to do to occupy my mind, with, let us say, the *vigor* that I was accustomed to, all my life—in aerospace, and in the military field. So I set about it, and the longer I worked at it, the more aggravated I became. And, since childhood, I've always been aggravated by opposition of any sort that the guys would want to put upon me, or whatever. . . . Finally, it had such a grip on me that I flew at this thing as I would at the enemy, in the two wars that I've participated in. It became my enemy. Now, mind you, at the very beginning, this was just a theory. I set up a theorem, in other words. If all these things could exist, then we could have a very, very great train system.

But, nevertheless, I didn't think I could do it. I didn't flatter myself that I could, and I knew nothing of maglev systems. I didn't even know what kind was being worked on. I heard rumors that the Germans and Japanese were working on some. At any rate, I continued my work and I knew I had to be able to control those magnets. That was the whole thing. I knew darned well I could lift a train, if I had magnets strong enough. But control, that was my huge problem, and I kept working away. Finally it occurred to me that if I had some method, just a natural method without any fancy computers and electrical stuff—I have never had any affinity for electrical work, just absolutely no feel for it, don't like it even yet, at least, to work with it.

So, finally one night—I had been working hard that particular night, and I went to bed about one o'clock. And I woke up very clear about one-thirty and I wondered, why did I awaken? So I went into the kitchen and sat down at my kitchen table, and I pulled out a grocery shopping bag, the kraft paper bag, you know, and a number two lead pencil, and I started sketching. Incidentally, I can't make a straight line, with a ruler, even—I'm very poor at that.

At any rate, it seemed that someone else took a hold of my hand. I didn't even know what I was going to sketch. I was just randomly sketching away there, and then, all of a sudden it hit me. An inspiration! It was that one percent, or that one tenth of one percent that Mr. Edison described—that inventions are ninety-nine percent perspiration, and one percent inspiration. So, I'll admit, I had this inspiration, and where it came from. I don't know. Some say it's God's Will, some say it's Destiny, and, in any event, it came to me, and before that hour was over, I had solved it.

Figure 2
CABIN AND LEVITATION COMPARTMENT FOR MAGNETRAIN
The levitation compartment is above, and the passenger/cargo compartment below, in this schematic of the Magnetrain.



between the underside of the cars and the ground would be maintained at a minimum of 18 feet. This would eliminate the need for grade crossings in populated areas, and allow the system to pass over agricultural land without disrupting production.

In Figure 2 we see the two principal parts of the train itself, the passenger or cargo compartment (below) and the levitation compartment (above). In Figure 3 we see a slice through the place marked *2* in Figure 2. This shows us the internal workings of the levitation system.

Let us examine Figure 3 in more detail. Part number 11 is a part of the cross-structure suspended between the towers, to which the steel rail is attached; it is probably made of pre-*stressed* concrete. Part 12 is the underside of the I-beam shaped steel rail, which is laminated to minimize the occurrence of induced, or eddy, currents when the magnet passes near it. The lifting magnets (21) are mounted on pistons, which can travel up and down in cylinders mounted directly below this rail. Next to each of the lifting magnets, in the inboard direction, are the smaller repulsive magnets (22), also mounted on pistons contained within cylinders (42). The repulsive magnets are positioned under strips of ceramic magnets (14), which run along the length of the *control track* (13).

The third pair of pistons (35) is mounted in the *weighing cylinders*. The inverted U-shaped structure (18) supports the weight of the passenger or cargo compartment (17). When additional weight is added to the lower compartment, such as by the loading of passengers or freight, it puts a downward force on the pistons (35), forcing oil in the weighing cylinders (36) to move through the tubes (37) into the cylinders (38), which contain the attractive, lifting magnets. The lifting magnet is thus forced upward, closer to the track, as is required to sustain the weight that has been added.

However, to assure that the lifting magnet does not continue moving closer to, and perhaps grab, the track, a compensating force is introduced by means of the repulsive magnet. As the piston (39) holding the lifting magnet moves upwards, oil in the upper part of its cylinder is forced out through the

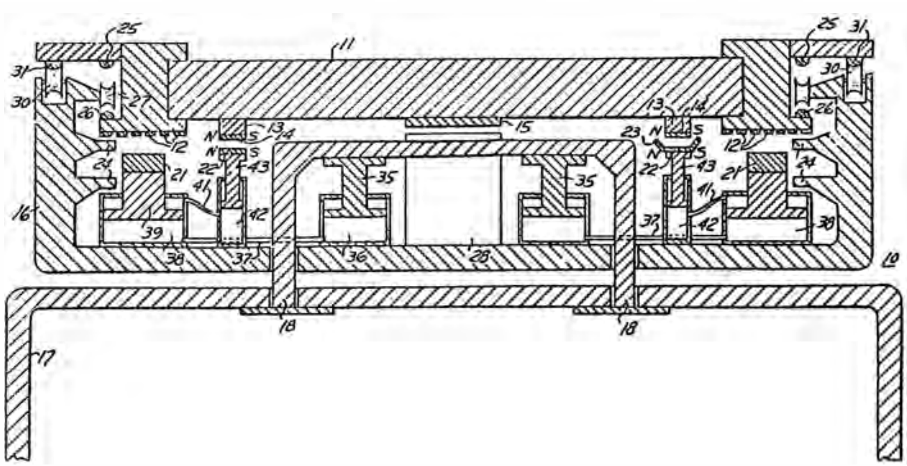


Figure 3
CROSS SECTION OF THE PERMANENT MAGNET LEVITATION SYSTEM
This cross section is taken from the place marked 2 in Figure 2. The numbered sections are described in the text.

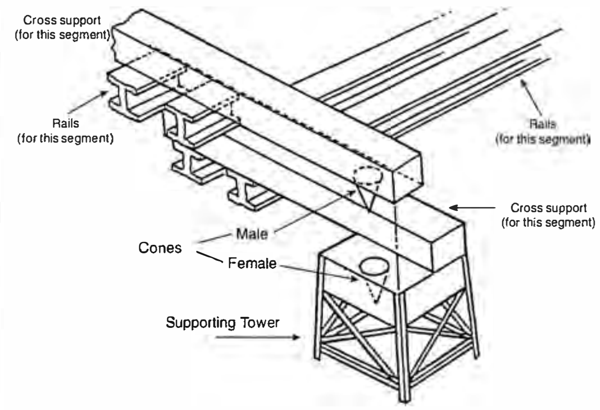
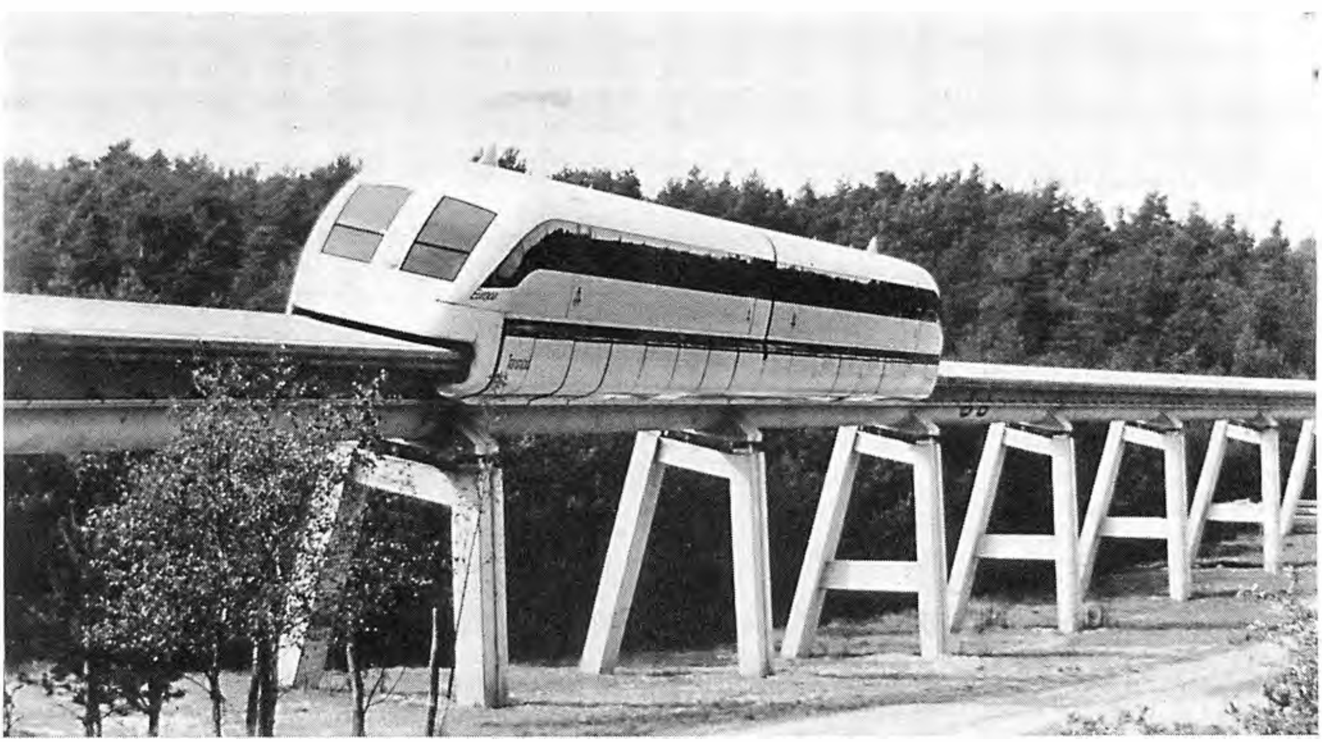


Figure 4
EARTHQUAKE-RESISTANT CONICAL MOUNTING OF RAIL CROSS SUPPORT
The cross support that holds up the track is not rigidly fixed to the tower structure, but is attached to the top of the structure by interlocking cones, which can realign segments if there is an earthquake.

connecting tube (41) into the cylinder (42), which contains the repulsive magnet. This reduces the air gap between the repulsive magnet and the strip of ceramic magnetic material which runs the length of the track, thus providing a compensating force to push the train away from the track. The levitation compartment is thus lowered with respect to the track. Gravity will force the passenger or cargo compartment to fall as well. That must cause a downward pressure on the oil in the weighing cylinders, causing the entire cycle just described to repeat itself.

The levitation of the train is thus a closed-loop system, controlled by hydraulic means. When the weight of the vehicle is increased, the hydraulically activated pistons adjust their positions to return the system to equilibrium with the levitation magnets slightly nearer the tracks. When the weight of the vehicle is reduced, the vehicle tends to move upward, causing fluid to flow from cylinders (42) into the upper part of cylinders (38), and from thence into the weighing cylinders (36). The net result is for the vehicle to be in equilibrium, with the levitation magnets slightly more distant from the tracks.

The hydraulic system for control of the magnets is unique. In the German and Japanese systems, very complex electronically controlled feedback devices are required to maintain the proper relationship of train and track. In the Magnetrain system, the closed hydraulic loop does this job. This may be supplemented by an additional system that would allow the magnets to react to very sudden changes in load, such as could be encountered from sudden wind gusts, or on turns. The original Magnetrain patent proposes a variety of ways to accomplish this. Basically, a sensor will detect a change in the air gap between the primary lift magnet and the track. Then, in one version, the information can be fed to an electromagnetic coil which is wound around the lift magnet. The amount and direction of the current flow through the coil will be proportional to the change in air gap detected by the sensor. In this way, the



The German Transrapid on its test track, at 500 km per hour.

flux of the lift magnet can be increased or decreased, almost instantaneously.

The Magnetrain system is the only one which requires no additional electricity at all to maintain lift. The atomic electrical circuits, which make up a permanent magnet, never have to be replenished.

Some Comparisons to the German and Japanese Maglevs

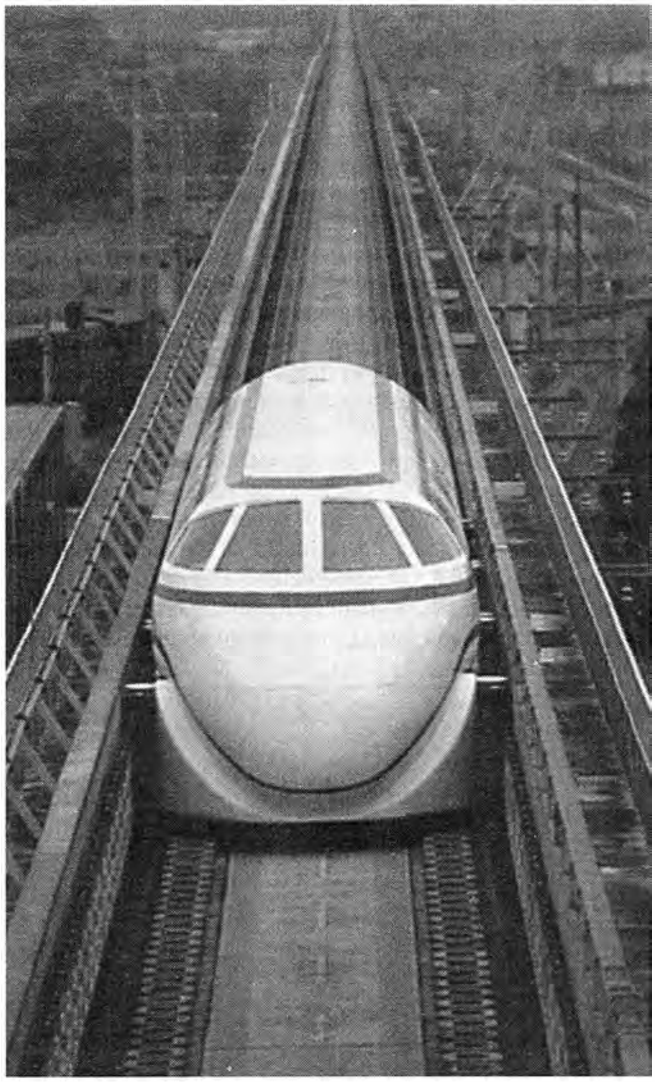
The German Transrapid 07 operates on-grade with a heavy track support structure, and a track that must be maintained to a very high-degree of flatness. To levitate the train, the track of the Transrapid flares out at the top, while flanges on the underside of the train cars reach around underneath the flare. Electromagnets, mounted in the wraparound flanges, then provide the lift, by pulling the train up towards the underside of the flared part of track. This type of maglev is known as an Electromagnetic Suspension System, or EMS.

The Japanese maglev train, the HSST, uses superconducting electromagnets to induce an electromagnetic repulsive force in the track, causing the train to levitate. This type of system is known as Electrodynamic Suspension, or EDS. The design is a variation of the one first worked out in 1966 by U.S. physicists James Powell and Gordon Danby of Brookhaven National Laboratories. Cryogenically cooled superconducting magnets in the train cars induce a current in the guideway (track) as the train moves forward. The induced current, by Lenz's law, creates a repulsive magnetic force which lifts the train off the guideway. Since the lifting force only becomes strong enough at about 30 km per hour, the train must use conventional wheels for takeoff and landing. The refrigeration systems needed to maintain superconduction are bulky and expensive. Another possible drawback is that passengers are exposed to very high-gauss magnetic fields below their feet. In Magnetrain, the magnets are isolated in a separate levitation compartment, above the passenger compartment.

One of the big advantages of Magnetrain over the existing German and Japanese systems is that Magnetrain is the only one that is designed for functioning *above-grade.* In the German and Japanese system, the train pulls or pushes itself from a complex track that must rest firmly on the ground. Elevating these trains is a very expensive proposition. Magnetrain is designed to hang from earthquake-resistant steel towers at a minimum clearance of 18 feet above the ground. Thus there is no problem of grade-crossings, one of the leading causes of train accidents today.

In cross-country applications, Magnetrain could cross over roads and farmers' fields without disrupting activity. Perforated metal mesh nets under the train would dissipate air flows, preventing dangerous air currents in areas where there is likely to be contact with human activity. The design is also particularly suited to crossing desert terrain, where sand accumulation can easily disable on-grade train systems.

In urban and suburban applications, the trains would run at less than the 600 mile-per-hour top speeds. In congested areas, the steel towers could be built right over existing roadways. Unlike the old urban elevated trains, they would make little noise, and the sleek design of the towers and track would cause little disruption of light. In the highly congested



The Japanese MLU 001 on its U-shaped guideway at the Miyazaki Test Track.

greater Los Angeles area, for example, Magnetrain inventor, Colonel Vinson, envisions construction of Magnetrain towers on the rather generous rights of way of existing freeways. Vinson has been a resident of California for more than 30 years, and is thus acutely aware of the threat posed by earthquakes. For this reason, he believes a subway system is fundamentally unsound for any earthquake prone location on the Pacific rim. In the 1981 patent, the basic design of a system of earthquake-resistant support towers is revealed. Since then, his friend and collaborator, engineer Theodore Anvick, who is a specialist in design of towers, bridges, and large structures, has worked out many refinements. The essential idea, embodied in the original patent, is illustrated in Figure 4. The portion of track running between each successive tower is a distinct segment. The cross support which holds up the track is not rigidly affixed to the tower. Rather, it is attached to the top of the tower structure by a male and female cone. In the words of the patent: "The purpose of these cones is to make a secure horizontal alignment of each segment with adjoining segments, and to regain such alignment, if disturbed by Earth movements."

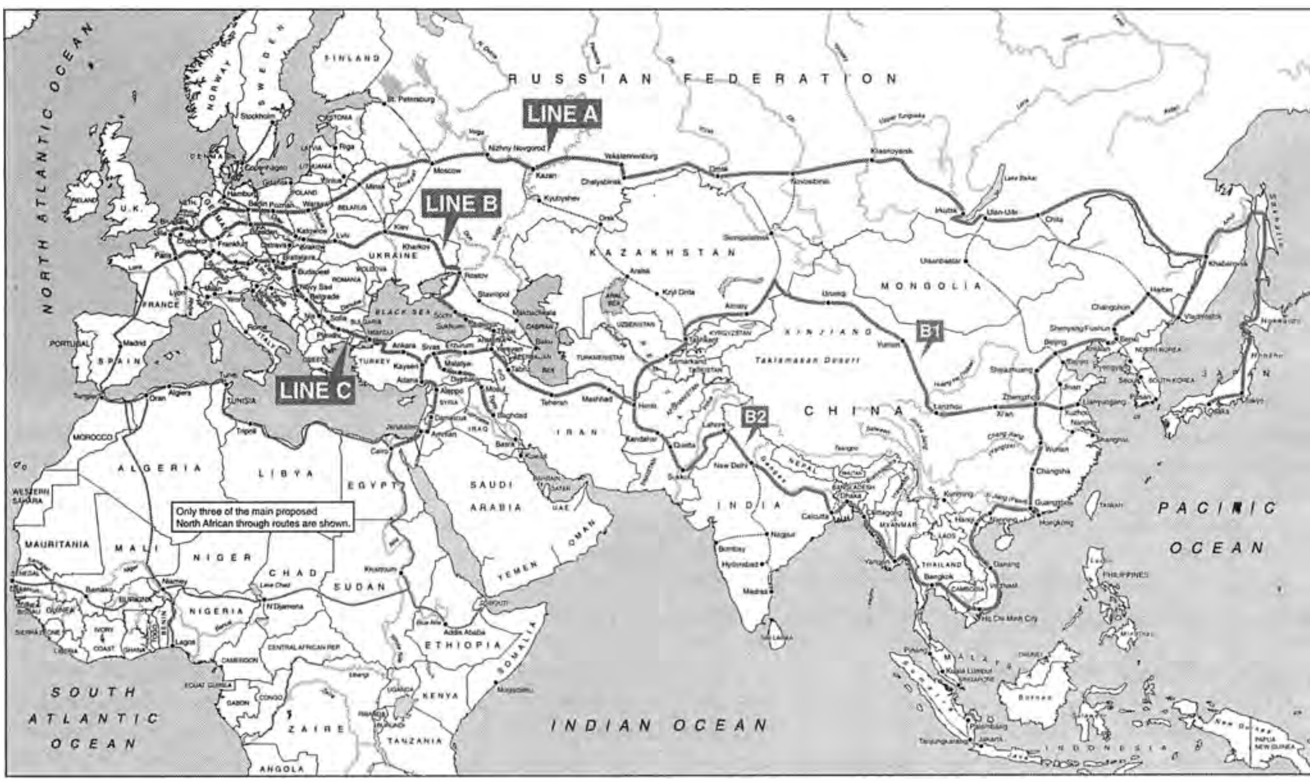
The Magnets

When Colonel Vinson began the work of designing the Magnetrain system in 1972, he was unaware of any magnet capable of supporting a train in the way he envisioned. Unbeknownst to him, a physicist by the name of Carl Strnat, working at the Air Force research laboratory in Dayton, Ohio, had just recently demonstrated the feasibility of a very powerful, new type of magnet made out of an alloy of Samarium, Cobalt, and Iron. Samarium is one of the Lanthanide series of elements that falls between atomic numbers 57 and 70. They are known as "rare earths," a misnomer since they are neither "rare" nor "earths." The secret to the new type of magnets lay in Dr. Strnat's insight into the crystal anisotropy of alloys made with rare earth elements. Essentially, the peculiar crystal structure causes the iron atoms to be "frozen" in place, such that they are not disoriented when exposed to countervailing magnetic forces.

The measure of the strength of a magnet is the product of the inherent magnetic force, contributed solely by the presence of iron atoms, and its resistance to an opposing magnetic force, which is known as *coercivity.* The inherent magnetic force retained by a permanent magnet, after it is no longer exposed to a magnetizing influence, is known as *remanence*. The product of the remanence into the coercivity, known as the BH product, is a good measure of the strength of a magnet. Although a rare earth magnet can never have as high a measure of remanence as one made of pure iron, its resistance to demagnetization can be so much greater, that the end result is a much more powerful magnet.

Before 1970, the strongest magnets were of the type known as Alnico, an alloy of Aluminum, Nickel, Cobalt, and Iron. The BH product of the best Alnico magnets reached about 80 kilojoules/m^3. By 1980, Samarium Cobalt magnets had achieved a BH product of about 240 kilojoules/m^3, three times greater than Alnico.

In 1984, researchers at the General Motors Research Laboratory and in Japan discovered an even stronger type of rare earth magnet using an alloy of Neodymium, Iron, and Boron. Neodymium-Iron-Boron magnets now achieve a BH-product of about 400 kilojoules/m^3, five times greater than any magnet existing up to 1970. These Neodymium magnets



Map shows existing and probable routes of an intercontinental landbridge linking three continents, as conceived by international statesman Lyndon LaRouche. High-speed rail freight and passenger transportation is a crucial element in raising the rate of productivity of the world economy such that rapid development of the underdeveloped world can take place, LaRouche argues. Corridors of 50- to 100-kilometer width along the rail routes will be the loci of new urban and high-technology, agro-industrial development. China already conceives of such a scheme to overcome the poverty of its central interior regions. It is also a necessity for the development of Africa, where most regions are now suffering from civil war and pandemic diseases.

Source: Executive Intelligence Review, *The Eurasian Land-Bridge: The 'New Silk Road'—Locomotive for Worldwide Economic Development*, 1997 are now readily available in many sizes and shapes.

Neodymuium-Iron-Boron magnets have a lift ratio of 270 to 1 with a one-inch air gap. That means that 740 pounds of such magnets will lift a train car weighting 100 tons, making it perfectly feasible to carry freight cross-country at high speed, on a Magnetrain system.

How Soon Can We Have Magnetrain?

The principal shortcoming relating to Magnetrain has nothing to do with the design or feasibility of the system. It is in the poor reception it has so far received, especially in the United States.

Magnetic levitation systems have been on the drawing boards since 1912 , when an eddy-current repulsive levitation scheme was proposed by French engineer Emile Bachelet. Beginning in the late 1960s, research and development efforts were carried out at Ford Motor Corp., Stanford Research Institute, Massachusetts Institute of Technology, and Princeton and Cornell universities, among other U.S. locations. In the 1980s, government-funded programs at a number of major U.S. aerospace corporations completed designs and scale models of various types of maglev train systems. In November 1991, the National Maglev Initiative of the Federal Railway Administration awarded $8.6 million to the Bechtel, Foster Miller, Grumman, and Magneplane corporations for development of maglev system concepts. The designs were completed in a year and reviewed in the National Maglev Initiative's Final Report of November 1993. A number of states, including Alabama, Pennsylvania, and California have sponsored maglev study programs. Despite all these U.S. initiatives over more than 30 years, the irony is that the Germans and Japanese, with far fewer resources, persevered and completed their systems.

Colonel Vinson believes that Magnetrain will prove itself far superior to the German Transrapid and Japan's HSST. Vinson thinks especially highly of the German maglev development effort, but because of the drawbacks earlier stated, he does not believe that either the German or Japanese systems can prove commercially viable in any large-scale application.

The next step for Magnetrain is the production of a working scale model. In the early 1990s, a major U.S. aerospace corporation approved the Magnetrain design, and came very close to funding a scale model program. At the last minute it was dropped, but not because of any objection to the soundness of the concept. In fact, the soundness of the Magnetrain levitation system has been attested by the two foremost experts on magnetism in the world, Dr. Rollin J. Parker and Dr. Klaus Kronenberg. Parker describes Magnetrain as one of the promising applications for the powerful, new rare earth magnets, in his comprehensive work on the subject, *Advances in Permanent Magnetism.*[3]

Klaus Kronenberg is a German-born physicist who, in 1948, was the first person to demonstrate that there could exist permanent magnets which did not lose their power over time. He came to the U.S.A. in the 1950s, and has worked here since. Formerly a consultant to both the U.S. and West German governments on maglev technologies, he has seen first hand the Transrapid, and many U.S. designs. About a decade ago, Kronenberg, who was living in the same area of California, met Colonel Vinson, somewhat by chance. He now believes that Colonel Vinson's Magnetrain system is the most viable of all the existing designs. The production of a working scale model is now the priority of Vinson and his small circle of collaborators.

Vinson envisages a U.S.-led crash program to build magnetic levitation systems around the world, modelled on the Apollo Project, which he participated in, and the World War II Manhattan Project. With the proper backing from government and industry, he believes he could develop the system to where we could start installing a revenue-producing system in five years. A hero of World War II, he has never given up the vision, shared by so many Americans returning from that war, of a United States committed to using its great technical and scientific talents for the peaceful development of the world. His vision of Magnetrain is of a great instrument for uniting the people of the world, connecting continents, and improving the life of all mankind.

Laurence Hecht is Editor-in-Chief of 21st Century *magazine.*

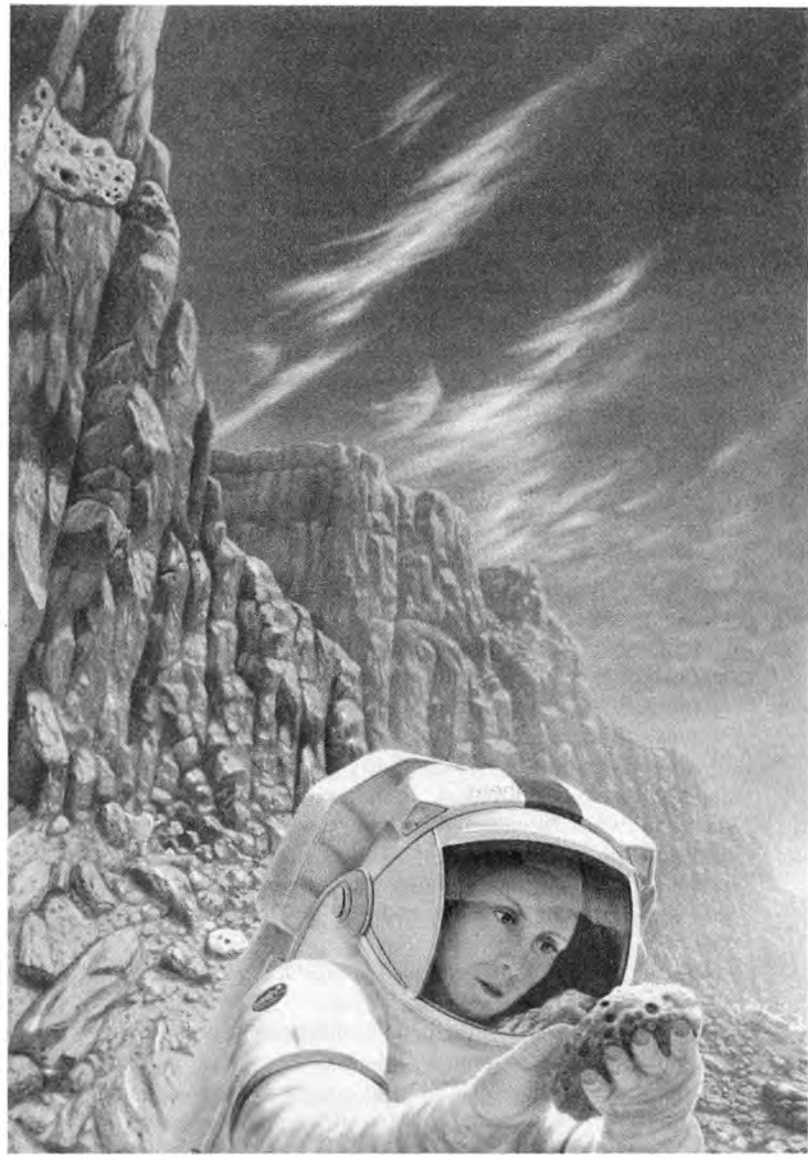
Notes

1. A combination of factors led to the near-destruction of the magnificent freight and passenger railroad system, whose extension and development had been synonymous with the growth of the United States from colonial status to the world's greatest economic power. These destructive influences included: the looting of the railroads by Morgan, Rockefeller, Harriman, and other financial interests, whereby investment in maintenance and replacement of rail and rolling stock was drastically cut, in order to produce an apparent higher rate of return on invested capital; the postwar collusion of General Motors with the oil monopolies to replace urban electric-trolley and light-rail systems with gasoline and diesel-powered buses; the construction of the Interstate Highway System, which, while not evil in itself, served as a taxpayer subsidy to cheapen the apparent cost of trucking over rail; the bureaucratic slowness of the railroads to adopt modern systems of tracking, warehousing, and freight handling.
2. U.S. Patent No. 4,307,668, Dec. 29, 1981.
3. Rollin J. Parker, 1990. *Advances in Permanent Magnetism* (New York: John Wiley & Sons).

Terraforming Mars To Create A New Earth

by Marsha Freeman

Space scientists are now working on bold new plans to take the first steps to make all worlds habitable for future generations.



Pat Rawlings/SAIC/NASA

Terraforming Mars will require a series of interventions on the planet, in order to make the atmosphere thick and warm enough for microbial life. During that time, exploring Mars will require space suits, as seen here. Eventually, however, people will able to walk around the surface unencumbered, at home on their new Earth.

What greater representation can there be of mankind's creative genius, than for him to move off his home planet, and extend life throughout the Solar System, by creating new abodes for life, new Earths? In the 1938 article translation in this issue, the great Russian biogeochemist, Vladimir Vernadsky, wrote that the geological region of life on Earth—the biosphere—has been "extended through man's machines into the stratosphere." A decade before Vernadsky's article, Hermann Oberth, the father of spaceflight, wrote that the goal of using machines for future manned space exploration was not merely to venture off the surface of the Earth, but "to make all worlds habitable."

Now, for the first time, man has at his fingertips, the tools that can be used to move human civilization into space. Now, too, we can plan the steps that will be required to create new Earths.

Although Earth's Moon is the nearest and most convenient object for exploration and settlement, that small celestial body is unable to support the atmosphere upon which life would depend. Life on the Moon will require an enclosed and protected habitat.

Mars, although more difficult to reach, has all of the ingredients necessary for life. Now a likely lifeless planet, Mars once had an atmosphere thick and warm enough to allow for the flow of liquid water on its surface—the prerequisite for life. And once there is again an atmosphere that will allow the existence of liquid water, there will be life on Mars. Terraforming Mars, therefore, is first a "restoration" project, to return the now cold, dry planet to a more potentially life-like period in its geological past.

The First Step: Ecopoiesis

Because the atmosphere of Mars today is composed primarily of carbon dioxide, it will not support aerobic life—animals or man. The first step in terraforming Mars will be to warm up and thicken the existing atmosphere in order to make Mars habitable for the anaerobic micro-organisms that can prosper in a carbon dioxide environment.

This process has been termed *ecopoiesis* by biologist Robert Haynes—from the Greek, meaning fabricating or producing an abode or dwelling place. The process of ecopoiesis on Mars will require the transformation of what Vernadsky terms the "bio-inert bodies" of the planet—the soil, atmosphere, and water—which play a large role in the organization of the future biosphere, and, in turn, are "changed by the living matter within them."

Today, the temperature on Mars only reaches the melting point of water (273 degrees Kelvin) for very short periods of time, and this only in the equatorial regions of the planet, when it is closest to the Sun in its elliptical orbit. Although there are niches where life on Earth can exist in such an extremely cold and dry environment (for example, in Antarctica), the unmitigated bombardment of ultraviolet radiation on the surface of Mars, because of the lack of an ozone layer in the atmosphere, makes it extremely unlikely that any biological species could presently exist there.

Even if the atmospheric temperature of Mars were slightly above freezing, and there were an ultraviolet shield, no life form could survive, because the pressure of the carbon dioxide atmosphere of Mars today is only about 1 percent that of the atmosphere of the Earth at sea level; less than 10 millibars (mb). We know of no currently existing microorganisms that could withstand such low atmospheric pressure.

Embarking upon the ecopoiesis of Mars, therefore, requires raising both the atmospheric temperature and pressure of the planet, which go hand-in-hand. Because Mars has a store of carbon dioxide, in at least two forms beside the gas already in the atmosphere, it is the release of that frozen and chemically-bound carbon dioxide that can warm the planet and increase the pressure, enough to accommodate anaerobic forms of life.

It has been well known for decades that the permanent south-polar cap of Mars is primarily composed of frozen carbon dioxide (dry ice), while the north pole, which recedes with the seasons, is primarily water ice. It is also generally believed that there is also a storehouse of frozen carbon dioxide mixed in with the Martian soil, as a kind of permafrost. In addition, it is quite likely that the soil on Mars, contains carbonates, especially in regions where there is evidence of water flow on the surface. These carbonates were probably formed when some of the atmospheric carbon dioxide was dissolved in water, and combined with other elements such as calcium, iron, and magnesium.

Estimates of the inventory of carbon dioxide on the planet—and also water, other volatiles, and minerals—differ by orders of magnitude. What we know about the composition of Mars was revealed by the Viking landers of the 1970s, meteorites that have found their way to Earth from Mars, and the more recent Mars Pathfinder mission. For this reason alone, it is still somewhat speculative to propose a precise plan of action for terraforming Mars. But the goals are clear. The models being developed will improve in accuracy as the next decade's missions reach Mars, and the technological tools for planetary engineering continue to advance.

Starting a Runaway Greenhouse Effect

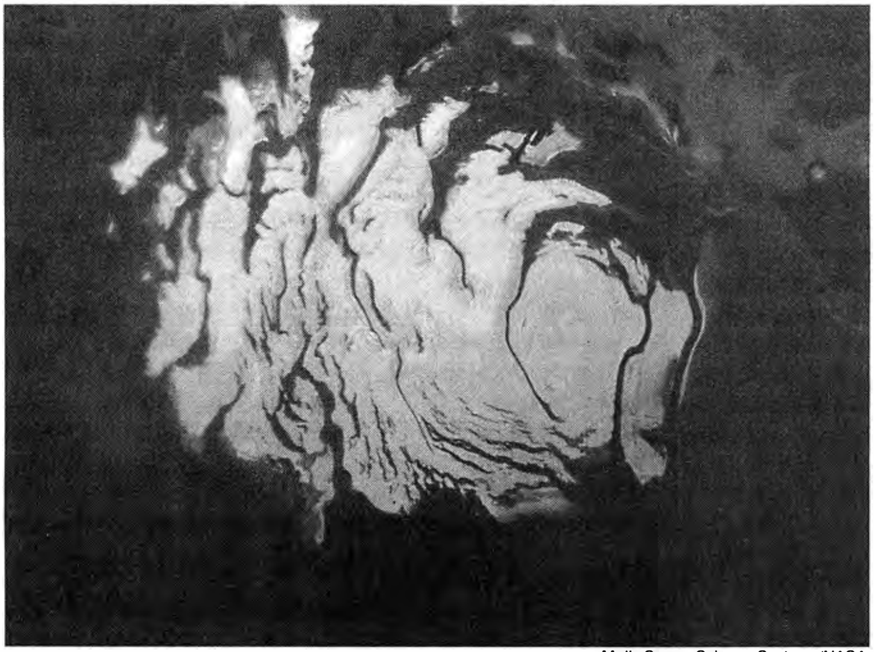
Various means have been suggested to raise the temperature and pressure of the red planet, to get the process started of liberating the carbon dioxide now frozen in the south polar cap and in the surface layer of soil, known as the regolith.

U.S. Geological Survey

It is evident that, at some time in the past, there was flowing water on Mars, creating the precondition for life. Beautiful Vallis Marineris (seen here), a canyon the width of the United States, was created by the action of flowing water. There are steep cliffs and what appear to be layers of sedimentation.

Planetary scientist Chris McKay has estimated that a 4° K increase in the south polar temperature would, for example, over perhaps just a decade, melt the cap, releasing between 50 and 100 mb of carbon dioxide into the atmosphere. At the current time, the atmospheric pressure at the pole is about 6 mb. As the planet warmed from the polar cap release, frozen carbon dioxide in the regolith would begin to be liberated. This combined release eventually could add up to 400 mb of carbon dioxide into the atmosphere, which, in total, could increase Mars's temperature up by 55° K, well above the freezing point of water.

One method proposed for such a heating project, is the deployment of one or more orbital mirrors to concentrate sunlight onto the south polar surface. But to concentrate enough solar energy onto the pole, McKay estimates the orbiting mirror would have to be the size of the state of Texas, which seems hardly practical. Other proposed methods, which are also untried, include decreasing the albedo at the poles by



Malin Space Science Systems/NASA

The south polar cap of Mars, composed primarily of carbon dioxide, will be investigated as a source of volatiles to thicken and warm the atmosphere of Mars. This photograph, taken by the Mars Global Surveyor on April 17, 2000, shows the cap in summer, when it has shrunk to its minimum size, with remaining large deposits of frozen carbon dioxide. The image shows an area 420 km (260 miles) across.

scattering dark-colored dust there, in order to increase the absorption of sunlight, and smashing asteroids into Mars to add to the stock of gases in the atmosphere.

An approach which is more seriously being considered, and which has as its precedent the evolution of the conditions on the planet Venus, is to use super-greenhouse gases to induce a runaway greenhouse effect. A suitable gas must have the property that it does not absorb the visible light needed to heat the planet's surface, but does absorb the infrared (heat) radiation re-emitted from the planet, preventing its escape back into space. One candidate has been the class of chlorofluorocarbons. But the drawback of CFCs is that high levels of ultraviolet radiation—which will be present on Mars until there is a protective ozone layer in the atmosphere—would break their chemical bonds. This would result in a lifetime of only hours for CFCs in the Martian atmosphere.

A more productive line of inquiry is the use of perfluorocarbons (PFCs). McKay has estimated that only a few parts per million of these super-greenhouse gases, could raise the average surface temperature on Mars from −60° to −40° Celsius, enough to trigger the natural release of carbon dioxide from the polar caps and the regolith, starting a runaway greenhouse effect. If the gases can trap sunlight with a 10 percent efficiency, McKay has calculated, within 100 years, Mars would have a thick, and warm, carbon dioxide atmosphere.

During a two-day workshop held at NASA's Ames Research Center in California, Oct. 10-11, 2000, nearly 150 scientists discussed "The Physics and Biology of Making Mars Habitable." One of the presentations, by Massachusetts Institute of Technology student Margarita Marinova, described the most recent research on warming Mars using artificial super-greenhouse gases, including sulfur hexafluoride and PFCs.

On Earth, the major greenhouse gas is water vapor, little of which now exists in the Martian atmosphere. The second most effective, carbon dioxide, exists on Mars in relative abundance, but not enough to warm the planet.

Marinova proposes introducing those super-greenhouse gases into the atmosphere that can be produced from local Martian resources, rather than being imported. Such gases must also be approximately 20 to 30 times more efficient in trapping radiation than carbon dioxide; they must not harm a nascent ozone layer; must have long residence times in the atmosphere, and not be subject to break-up by ultraviolet radiation; and must ultimately be produced biologically. PFCs fit the bill.

In an interview, Ms. Marinova explained that the PFCs being considered have resident times in the atmosphere on the order of 3,000 years. They are not harmful to life, and will not affect the ozone layer, she said.

A Super-Greenhouse Gas Cocktail

Until recently, the spectral absorption bands for PFCs were unknown, but laboratory work by Hirofumi Hashimoto, at the Institute of Engineering Mechanics and Systems at the University of Tsukuba in Japan, and the modelling work being done by Marinova, have produced a profile of a "cocktail" of super-greenhouse gases that could have the greatest impact on the ecopoiesis of Mars.

Their work indicates that small amounts of gas will be adequate to start the formation of a thick carbon dioxide atmosphere on Mars, if the natural feedback mechanisms inherent in the Martian climate system can be activated. A mixture of gases is advantageous for two reasons. One is an effect called pressure broadening. It has been found that when a non-absorbing gas is introduced, it broadens the spectral lines of a radiation-absorbing gas, through collisions. On the Earth, the small amount of carbon dioxide in the atmosphere is an effective absorber because it is pressure-broadened by the ambient nitrogen and oxygen. On Mars, the trace gases are so insignificant, that there is no pressure-broadening of the carbon dioxide.

Second, there is a point at which increasing the amount of any specific gas reaches its limit of efficacy, as its specific spectral band becomes saturated. Once the gas has absorbed 100 percent of a specific bandwidth of radiation, it will not increase the temperature any further, no matter how much gas is added.

Therefore, using many gases at low concentration, the researchers conclude, will be more effective than using a small number, at higher concentration. Studying the characteristics of many potential super-greenhouse gases, each with different absorption bands, will allow planetary engineers to choose the best combination. The array of gases should block as much of the spectral band as possible, Marinova recommends, because "you can have a lot of radiation escaping even through a small [spectral] window that is not blocked by a gas."

In answer to a question concerning how quickly super-greenhouse gases should be introduced on Mars, Marinova responded, "as quickly as possible." Once you add greenhouse gases to the atmosphere, "the only timescale for how long it will take for them to warm up Mars, is how long it is going to take for them to mix in the atmosphere. Once they are there, on a geological timescale, it is almost instantaneous warming."

Marinova and her colleagues have asserted that it will be necessary to continue to add super-greenhouse gases to the atmosphere of Mars to keep it warm, even after the runaway greenhouse effect has liberated as much as possible of the carbon dioxide. She explained in her interview that first, it is not clear how much carbon dioxide there is on Mars, nor how much of it will actually be released into the atmosphere. But even if there is enough to make Mars habitable for microorganisms, once the second step is taken, of making Mars habitable for man, "the oxygen-rich atmosphere, that is low in carbon dioxide to be breathable for animals," will most likely require continued artificial warming. Super-greenhouse gases will have to be tailored to block out the sections of infrared radiation previously protected by the carbon dioxide.

All of the chemical ingredients for the production of super-greenhouse gases—carbon, fluorine, and sulfur—are already present on Mars, and to make this transformation of the planet economically viable, factories will be needed on site. McKay reports that calculations indicate that vaporizing the carbon dioxide and water on Mars, and evaporating nitrogen from the soil (defrosting Mars), would require an energy input of 5 megajoules per square centimeter of planetary surface. He reports that this is equivalent to about 10 years' worth of Martian sunlight. If the sunlight could be captured with 100 percent efficiency, this defrosting would take about 60 years.

Marinova has roughly calculated that deploying forty 700 MW nuclear power plants over a period of 100 years on Mars would allow the production of the quantity of super-greenhouse gases required for the ecopoiesis phase of creating this new Earth.

It is not known how much total carbon dioxide can be released into the atmosphere of Mars, or precisely how long it will take. Margarita Marinova reports that it is hypothesized that between .5 and 1 bar (between one-half and one Earth atmospheric pressure), will result from a runaway greenhouse effect on Mars. Chris McKay refers to these two levels as a "poor" Mars and a "rich" Mars.

But after less than a century, even at atmospheric pressure levels lower than those on Earth, people would be able to walk around the surface of the planet wearing only warm clothing and an oxygen mask. Microbes would have already established a foothold on Mars. With the addition of some oxygen and nitrogen, plants would be able to flourish, and mankind would have completed the first step in the process of moving along what geologist Martyn Fogg has called "the path from sterility through a continuum of improving habitable states."

From Ecopoiesis to Terraforming

The terraforming stage of development will be characterized by the activation of the hydrosphere, and the creation of an atmosphere that is breathable for animals and man; a habitable climate on Mars.

One of the most important effects of increasing the temperature of Mars to liberate the carbon dioxide, will be to increase the amount of water vapor in the atmosphere, enhancing the natural feedback mechanism that will hasten the further warming of the planet. But even after the completion of the expected runaway greenhouse effect on Mars, the planet will still be a quite cold and dry abode. Melting the ice situated in the permafrost, to allow the flowing water that once carved canyons and left river beds on Mars, will require Herculean efforts. Otherwise, we would be left to wait centuries for the somewhat warmer atmosphere to do the job itself.

Although further heating the planet to release the water

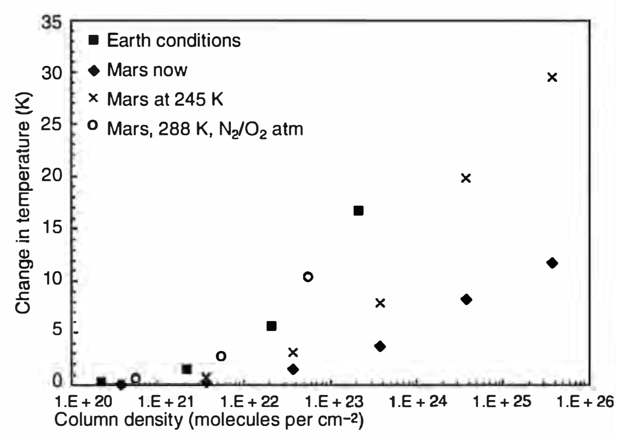


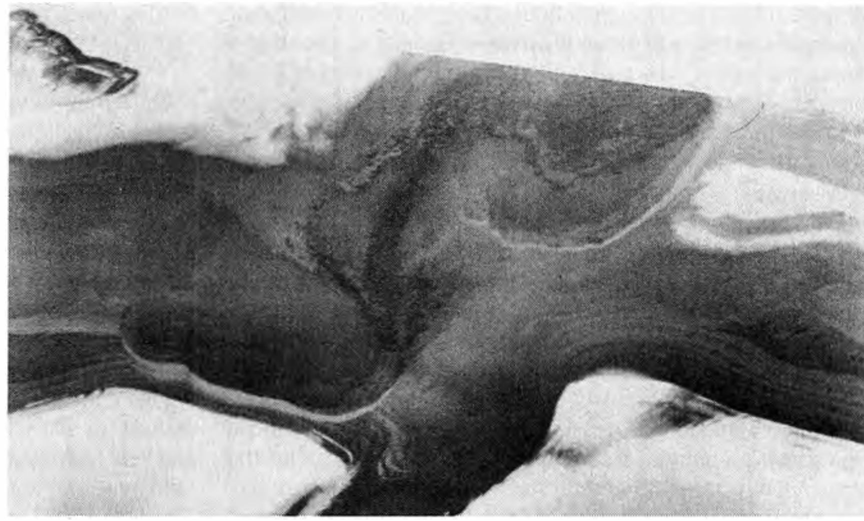
Figure 1
TEMPERATURE INCREASE FROM ADDITION OF SUPER-GREENHOUSE GAS

Here are four cases of the effect on the temperature on Mars from the addition of a super-greenhouse gas. The first case is the Earth as it is now. The second case is Mars as it is now. The introduction of a super-greenhouse gas on Mars would slowly raise both the temperature and pressure of the atmosphere. In case number three, with the help of super-greenhouse gases, the stage has been reached where the surface temperature has risen enough so that it is expected that the planet will be at the greenhouse runaway point. Most, if not all, of the available carbon dioxide will then be released into the atmosphere, warming it further.

In case four, the chemical composition of the atmosphere has been modified from 95 percent carbon dioxide, to the nitrogen/oxygen mixture required for life. That change, while necessary for man, would lower the temperature and pressure on Mars, conditions which would have to be maintained with continued supplies of small amounts of super-greenhouse gases.

Source: Marinova, et al.

The north pole of Mars is composed primarily of water ice. Because frozen carbon dioxide will sublime into the atmosphere at a lower temperature than water, what is visible in this summer photograph is the remaining water ice cap and the layered terrain underneath the pole. The photograph was taken by the Viking 2 Orbiter on Dec. 21, 1976.



JPL

might be feasible with asteroid impacts to the surface, this would hardly be feasible once living organisms had been introduced. Aerospace engineer Robert Zubrin and McKay propose that using the Project Plowshare method of detonating underground nuclear explosives would leave the planet unacceptably radioactive. Advanced fuel-cycle thermonuclear (fusion) explosives, with little radioactive by-product, could be considered. Zubrin and McKay point out that terraforming Mars may well be the driver that develops such fusion technologies, which are also required for enabling interstellar flight. Indeed, fusion propulsion will enable safe, expedient human flights to Mars.

The most challenging task for the terraforming of Mars, however, will be to transform its carbon-rich atmosphere to an oxygen-rich nitrogen atmosphere, similar to Earth's.

As Vernadsky points out, the significance of life in the biosphere is that it is "a planetary process." McKay echoes this truth: "the only mechanism that could transform the entire atmosphere is a planetwide biological process—the photosynthesis done by plants, which take in carbon dioxide and expel oxygen."

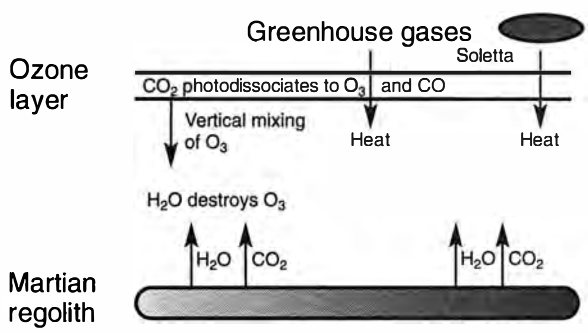


Figure 2
SELF-REGULATING OZONE CYCLE ON MARS
The creation of a protective ozone layer on Mars will be generated by the photo-dissociation of carbon dioxide. The heating of the atmosphere, by inert super-greenhouse gases and perhaps an orbiting mirror (the soletta proposal of space scientist Krafft Ehricke), will liberate frozen carbon dioxide and water from the Martian soil, increasing the temperature and atmospheric pressure. Although water vapor is a powerful greenhouse gas that can destroy ozone, it is hypothesized that a balance will be struck between the two processes, which can be helped along by the technological intervention of adding super-greenhouse gases.
Source: Adapted from Hiscox 2000

Microbiologist Julian Hiscox has extensively studied the biology of planetary engineering, and terraforming. He describes the initial microbial life that can be introduced on Mars when the conditions resemble those of Antarctica as "pioneer organisms." At the end of the runaway greenhouse period, there must be liberated carbon dioxide, increased atmospheric pressure, and water must be stable at least in niches on the planet. These early organisms he describes as psychrophilic, able to survive in a 288° to 293° K temperature. These would be capable of using sunlight as an energy source, but would not require complex organic material for metabolism.

Hiscox proposes that genetic engineering be undertaken, under simulated Martian conditions, to produce organisms that can withstand the desiccation (dryness) expected to persist on Mars. Experiments using Marsjars can prepare the way for the introduction of genetically engineered "marsbugs."

Before the introduction of plants, microorganisms could be used in the effort to transform the "bio-inert bodies," on Mars, in order to change the biosphere through the use of living matter within it. Pioneer organisms can be used to release carbon dioxide from carbonate deposits in the soil, increasing atmospheric pressure and temperature, and to metabolize nitrate deposits to create greenhouse gases—methane and ammonia—in order to augment the artificial super-greenhouse gases introduced by man. These preliminary steps will lay the basis for the introduction of oxygen-producing plants on Mars.

Speeding Up Life

But were plants to be the only method used, considering that the efficiency with which they produce oxygen from sunlight is only 1/100th of 1 percent, it would take more than a million years to convert Mars's carbon dioxide atmosphere to a breathable one. Although this sounds like a long time,

NASA

Estimates of the amount of water that is trapped in the regolith as permafrost, vary by orders of magnitude, and may provide a sufficient supply to warm the atmosphere. This 1979 photograph, taken by the Viking 2 Lander on Mars, shows proof that there is still water on Mars, in an accumulated thin layer of winter frost. But the trace amount of water vapor in the Martian atmosphere is not enough to be an effective greenhouse gas, and will have to be augmented by artificial infusions.

McKay reminds us, keep in mind the same process on Earth took more than 2 billion years.

Human intervention can augment this planetwide transformation, perhaps to a more manageable timescale of 100,000 years.

Zubrin and McKay propose that the first phase of creating an oxygen-rich atmosphere could be a "brute force" one, where terawatts (TW) of power are used to release oxygen from suitable "target material" containing oxides in the soil. After 25 years, they estimate, the 1 mb of atmospheric oxygen, needed for the support of higher plants, could be available. At that point, the thickened atmosphere and more temperate climate would allow the introduction of plants that have been genetically engineered, and naturally selected, to tolerate the Martian soil, and perform photosynthesis more efficiently than current species on Earth.

Over a few decades, global coverage of the planet with plants would produce the equivalent oxygen-producing power source of about 200 TW. If this were augmented with about 100 TW of power (terrestrial civilization today uses about 12 TW), the 120 mb of atmospheric oxygen required to support humans could be produced in about 900 years, they estimate. Man would be able to throw open the windows in his house on Mars, breathe the air, and directly oversee the new world that he has created.

And Mars would be just the first step. Hermann Oberth's goal of "making all world's habitable" would now be possible. As Zubrin and McKay state, "What is ultimately at stake is an infinite universe of habitable worlds."

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

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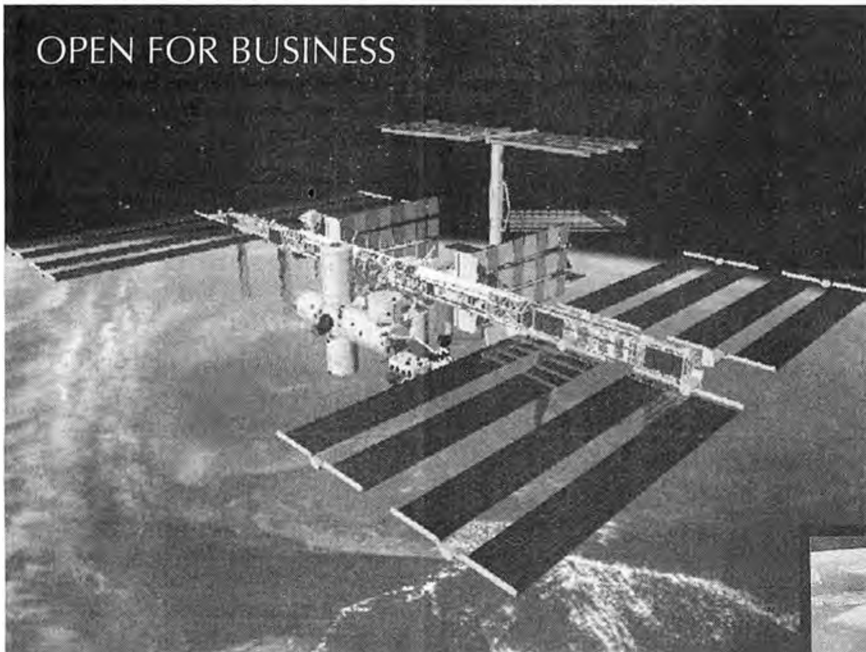
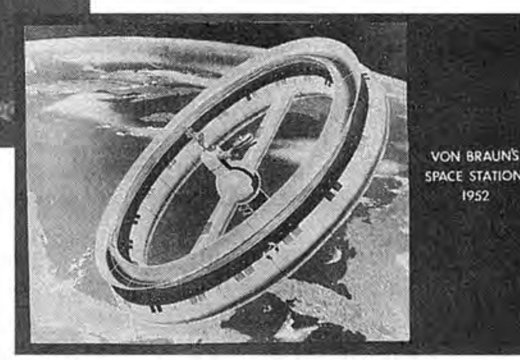
JPL/NASA

In the year 2003, NASA plans to send a pair of rovers to Mars, each carrying a suite of five scientific instruments to examine the history of the planet. These two "field geologists" will be providing the next on-site description of what there was, and is, on Mars. And a sample return mission in the next decade will bring us even closer to determining the inventory of volatiles on the red planet today, to help make it possible to do terraforming tomorrow.



◄ *Sixteen nations are building the International Space Station, seen here as an artist's concept. Projected for completion in 2006, the station will be powered by almost an acre of solar panels, and weigh nearly 1 million pounds. It will provide a set of world-class laboratories for scientific research.*

▼ *Artist's illustration of a 1950s space station concept by Wernher von Braun, which produced an artificial gravity by rotation of the wheel. Thousands of people would live and work on the station, which would also be a way station for more distant travellers.*



Space Station Begins New Era of Spaceflight

by Marsha Freeman

From the time that the visionary thinkers in space science realized that the technological breakthroughs to make spaceflight practical were imminent, their goal was to enable mankind to live in space. No one thought this would be an easy task. Just to survive, man would need an artificial biosphere, to create and replenish the air he breathes, isolate and eliminate the waste he produces, and provide the water and food he needs—things we barely think about in our daily lives on Earth. Human space travelers would need to be shielded from deadly radiation in space, and would need to withstand the physiological changes caused by the microgravity of the space environment.

Thoughtful plans for space stations go back to the turn of this century, when Russian theorist Konstantin Tsiolkovsky, and German visionary Hermann Oberth, were designing such homes in space, as the critical experiment for later sending travellers to the farthest reaches of the Solar System.

By the 1950s, after the successful tests of the first rockets during World War II proved that man would be able master the technology to reach space, fabulous space stations, designed by Wernher von Braun and depicted by space artists, presented a vision of virtual cities in space, housing thousands of explorers, many on their way to other venues.

Soon, the first steps in creating the capability for man to live and work in space would start to take shape.

The Historical Precedents

By the early 1970s, after the completion of relatively simple space missions to send people into Earth orbit for short periods of time (and return them safely to the Earth), the space agencies in both the Soviet Union and the United States were ready to see if men could work and live in space, not just visit there.

The Salyut series of Soviet space stations, from 1971 through the mid-1980s, and the American Skylab station in the early 1970s, proved that men could live in space, at least for months at a time, adjust to the space environment, and then re-adjust to the Earth's environment, without any debilitating effects.

When the first module of the more advanced Soviet Mir space station was launched in 1986, few in the West could imagine the complexity of the project upon which construction had begun. This core module, which is the model for the Zvezda Service Module now housing the Expedition 1 crew on the International Space Station, was the control and habitation facility for the Mir.

Over the course of a decade, five additional modules were added to Mir, each one a laboratory designed to study different aspects of space science, such as materials processing, life sciences, astronomy, and Earth observation. A fleet of unmanned Progress vehicles serviced the station with supplies and fuel, while cosmonauts set new records of endurance, spending more than a year in space.

But by the midpoint of Mir's life in orbit, the chaotic political and financial developments, and then the dissolution, of the Soviet Union, opened up the formerly secret program, and brought an opportunity for the Russians to join forces with NASA—the only other manned space program—to continue to service, and to upgrade the Mir.

The Shuttle-Mir program, during which seven American astronauts joined cosmonaut crews for long-term stays aboard the station, between 1995-1998, strengthened the cash-strapped Russian effort. More sophisticated American scientific equipment, as well as logistics and supply support, breathed new life into an aging facility. More than 100 American scientific experiments were carried out during the joint program, adding to the research that Russia and other Eastern European scientists had deployed aboard Mir.

The American space program learned lessons on how to do everything, from delicately docking huge Space Shuttles to an orbiting station, to learning what techniques can be used to give psychological support to crew members in an isolated environment, over long periods of time. Just as the United States had saved years of experimental rocket work by making use of the top German space engineers who came to America after World War II, the joint work with the Russians taught NASA how to assemble, supply, and operate a space station.

The Shuttle-Mir program was but the first step, however, in a long-term program to join together the only two manned space programs in the world. The next step is now under way, the assembly of an International Space Station, which is based on the combined technological experience and expertise of both nations, and involves the emerging manned space capabilities of the European Space Agency, Canada, Japan, and Brazil.

The new station is not designed to operate in a "survival mode," where coping with the problems of living in space is the primary task. The goal of the station is to use the most sophisticated technologies to make living in space routine, in order to allow crew members to concentrate on work in world-class scientific laboratories, carrying out experiments for scientists on the ground. Indeed, some of the scientists are becoming astronauts, and will accompany their experiments to the station.

Assembly Required

Before scientist-astronauts can move in to their new laboratories, the International Space Station will have to be assembled. By the time it is completed, in 2006, there will more than 100 components making up the facility. This enormous job will require 35 more Space Shuttle flights to the station, to deliver hardware and supplies (and also to bring up and return crew members), flights on Russian Soyuz vehicles for crew rotations, and unmanned Russian Progress cargo ships.

In the future, the European Space Agency plans to use its Ariane 5 rocket to deliver supplies to the station, as does Japan, with its H II rocket. In addition, an entirely new spacecraft, a crew return vehicle, is being developed, which will be parked at all times at the station, to bring a full crew of seven home in case of an emergency evacuation.

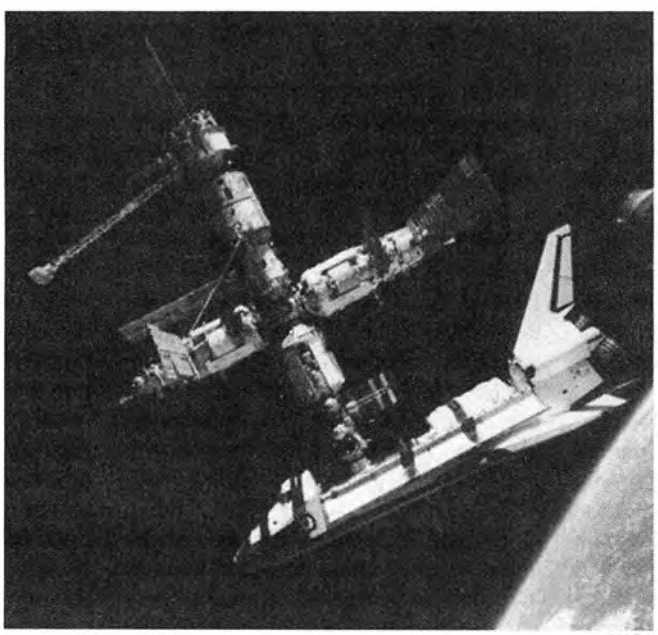
Before the scientific work can begin, the residents of this fledgling city in space must have a place to live. The first segment of the ISS, the Russian Zarya module, was launched in November 1998 from Kazakhstan, to be the anchor to which subsequent elements could be attached. Zarya must be able to hold a steady attitude in orbit, and so it is outfitted with navigation and control equipment for orientation. It's 16 fuel tanks feed two large main engines, used to reboost the station as its orbit lowers (as a result of atmospheric drag), and smaller control jets to keep it in proper alignment.

Its small solar arrays provide 3 kilowatts of power for its equipment. The module is equipped for automated rendezvous and docking, a system that was used successfully to attach the Zvezda living module to the station a year and half later.

Only two weeks after Zarya reached orbit, the United States launched the Space Shuttle Endeavour, which delivered the Unity module to the station. This node provides docking ports for the U.S. components for the station, as well as storage space. Unity is the passageway between the modules, and contains more than 50,000 mechanical items, such as lines to carry fluids and electrical cables, in addition to computers for command and control of the station, and a communications system.

In July 2000, the critical Zvezda module, which is the living quarters for the first crews, was added to the station. Two Space Shuttle flights, and an unmanned Progress supply ship, delivered thousands of pounds of supplies to the station over the following three months, readying it for its first occupants. With the activation of the Zarya module by a

Continued on page 72



NASA

This photograph of the Space Shuttle Atlantis, docked to the Russian Mir space station, was taken by cosmonauts Anatoly Solovyev and Nikolai Budarin as they flew around the station in their Soyuz capsule, on July 4, 1995.

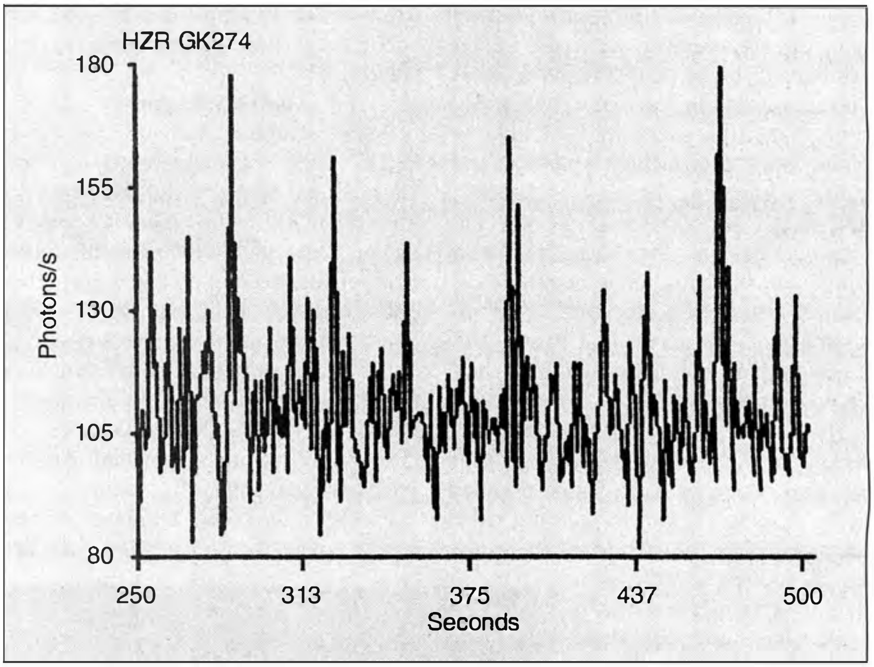
THE COMING REVOLUTION IN BIOPHYSICS

Russian Scientists Replicate 'Impossible' Mitogenetic Radiation

by Jonathan Tennenbaum

A heated debate recently erupted among biologists and physicists at Moscow State University, about a series of experiments by A.B. Burlakov and his collaborators, demonstrating non-linear interactions between living organisms, ostensibly mediated by electromagnetic radiation alone. The results of the experiments were so striking and unexpected to many of the Moscow biologists, that they were initially dismissed as "impossible." A number of the skeptics tried the experiments themselves, and were astonished to find *exactly* the effects reported by Burlakov et al.

In fact, back in the 1920s, the famous Russian biophysicist Alexander Gurwitsch had already established beyond any reasonable doubt, that living cells and tissues generate an extremely weak, yet *biologically active,* form of electromagnetic radiation, in particular in the ultraviolet range; and that the presence of this radiation is somehow intimately connected with the nature of living processes themselves.



Doing the impossible: Shown here is the low-level luminescence of cucumber seedlings, in photons per second, observed in the laboratory of Fritz Popp, between 250 and 500 seconds in the course of time.

Source: Fritz Popp, 1985. "Principles of Quantum Biology As Demonstrated by Ultraweak Photon Emission from Living Cells," *International Journal of Fusion Energy,* Vol. 3, No. 4 (Oct.).

Gurwitsch was led to his experimental demonstration of what he called "mitogenetic radiation" in a lawful and rigorous way, as a by-product of his attempts to hypothesize a *universal biophysical principle,* the which (among other things) would encompass the paradoxical, but otherwise undeniable correlations between events of cell division (mitosis) and other events occurring in widely separated locations within a living organism.

Gurwitsch's work, like that of his great Ukrainian-Russian scientific contemporary Vernadsky, was a direct outgrowth of the work of Louis Pasteur, and ultimately of Kepler and Leibniz. Exactly for that reason, it was systematically *suppressed;* both in the West—where the Rockefeller Foundation directly targetted Gurwitsch's and related work from the late 1920s on, as a threat to its promotion of reductionist "molecular biology"—and, to a somewhat lesser extent, in the Soviet Union itself.

The oligarchical effort to shut down Gurwitsch, and other branches of the Leibnizian/Pasteurian thrust in biology and medicine in particular, went hand-in-hand with the promotion of fascist eugenics policies, both in the crude form of the Harriman-sponsored Nazi "race hygiene," and the retooled, purportedly more "objective" and "scientific" version, now being propagated under the cover of the "human genome project" and the marriage of molecular biology with the doctrines of information theory and so-called "computer science." In fact, there has been no interruption in two centuries of British-centered efforts to use "biological theories" as a prime vehicle for propagating fascist doctrines, policies, and movements. The swindle of "artificial intelligence" and the now-booming pseudo-scientific discipline of "artificial life," amount to the same thing: the attempt to eliminate human cognition, to eliminate the concept of Man in the living image of God, and to propagate a bestial concept of society.

Mitogenetic Radiation Denied

The immediate *modus operandi* for the attack on Gurwitsch et al, implemented by the Rockefeller-sponsored scientist A. Hollander, and others, was to deny the very existence of mitogenetic radiation, dismissing it as an artifact or even a fraud. Gurwitsch himself was criticized as a "sloppy experimenter," or worse. Thereby, the entire work of Gurwitsch and his school—who for decades had applied the effect of mitogenetic radiation as a crucial experimental method, and had made countless new discoveries in biology and medicine on that basis—was dismissed as invalid and worthless. After 1945, only a small group of researchers, nearly all in the Soviet Union, tried to continue the thrust of his work.

Alexander Gavrilovich Gurwitsch (1874-1954) developed the theory of the biological field, and discovered that the emission of coherent photons from cells in mitosis, could trigger mitosis in other neighboring cells.

Today, however, the situation has changed, thanks in part to the direct, and indirect, influence of the work of Lyndon H. LaRouche. The LaRouche movement's campaigns around HIV/AIDS and the urgency of fundamental breakthroughs in biophysics in the face of a threatened biological holocaust, had some effect in parts of the scientific community: The recent controversies in Moscow University are connected with a beginning revival, both of Gurwitsch's work and of other directions of experimental research, growing out of the Pasteur-Leibniz current.

In the meantime, the original accusation against Gurwitsch et al.—that the mitogenetic radiation does not exist at all—has been swept aside. In 1954, a group of Italian astronomers, who had developed sensitive light detectors (so-called photomultiplier tubes) for the purpose of observing faint stars, tried their apparatus out on the leaves of plants. Immediately they found an extremely weak, but constantly "flickering" light emission by plant tissues. Was this the "mitogenetic radiation" of Gurwitsch?

Beginning in the mid-1970s the German physicist Fritz Popp began to perfect the method of "ultraweak photon detection" by specially designed photomultiplier tubes, as a method for investigating living organisms. Today, this work is being pursued in many countries, including Germany, Holland, Italy, Russia, China, and Japan.

Its Just 'Noise'!

As it was no longer possible to deny the existence of an "ultraweak" electromagnetic radiation by living cells, the opposition shifted ground: "Yes, the radiation exists, but it is far too weak to have any biological significance. It is a kind of *noise* from the chemical reactions going on in the tissue!"

Indeed, when estimated in the scalar terms scientists are trained in, the *average energy* of the detected "biophoton radiation" of living tissue, is practically *infinitesimal* compared to the energy of the ordinary metabolic (chemical) processes in the tissue—by a factor of at least 10 billion! How could such a tiny perturbation have any significant biological effects?

More insidious, is the attempt to interpret the "biophotons" emitted by living cells as "information"—a supposed, nominalistic sort of cell-to-cell "signalling," analogous to the way molecular biologists imagine cell processes to be triggered and regulated by the release of "signal molecules." This idea aborts the actual implications of Gurwitsch's and related work, by arbitrarily superimposing the sterile and false assumptions of "information theory," "nonequilibrium statistical thermodynamics," and related monstrosities, going back to Boltzmann, Wiener, and Von Neumann! One of the culprits is Ilya Prigogine, whom Dino De Paoli has dissected in a notable article.[1]

Let's now go back and see what the recent fuss at Moscow University was about.

The Moscow Experiments

Burlakov chose as the most suitable objects for his investigation, batches of fertilized fish eggs at various well-defined stages of development. In the marvellous process called embryogenesis, a complex and highly differentiated organism is generated, beginning with a single cell, through an series of successive transformations and developments, occurring in a specific order and timing. A trained embryologist, examining a developing egg with the help of a microscope, can immediately identify the stage the process has reached at any point.

Burlakov placed a batch of living fish eggs, all at some given, common stage of development, into a flat, hermetically sealed container that had a transparent window of quartz or glass at the top. Then he placed a second batch of eggs at the *same* or a *different* stage of development, into a similar container, but with a window at the bottom. He stacked the second container onto the first one (so that the two windows matched), and placed the stack in a closed, dark chamber under controlled conditions for a certain period of time. After the elapse of that time, the two containers were separated, incubated separately for an additional period, and finally the eggs in each of the two batches were examined under a microscope, to determine their condition and stage of development.

Burlakov found the following:

If the two batches consisted of eggs that were taken at the *same* stage of development, there was no noticeable change in the pace and other characteristics of development of either batch, compared to their expected normal development.

When one of the two batches consisted of eggs at an *early* stage of development, and the other at a *slightly more advanced stage,* then development of the younger batch was noticeably and consistently *accelerated,* relative to its normally expected development.

But when, instead, the second batch was selected from eggs at a much more advanced stage of development, the development of the eggs of the younger batch was *strongly retarded,* and the frequency of malformations and mortality among the younger eggs increased.

More generally, if the development (age) gap between two sets of eggs was small, then the development of the younger batch was accelerated; while if the development gap was large, development was retarded.

These effects occurred consistently, as long as *quartz* windows were used on the containers containing the eggs; but the effects disappeared immediately when the quartz windows were replaced by windows made of ordinary optical glass, or when pieces of black paper were inserted between the two stacked containers. This observation is consistent with Gurwitsch's original conclusion, that the observed change in the behavior of the eggs depends on the transmission of *ultraviolet radiation* between the two batches. For, quartz is relatively transparent for ultraviolet light, while ordinary glass blocks or attenuates it.

A Moscow biologist noted, that in nature, fish generally avoid laying eggs at a location where other eggs have already been laid. Probably, pulses of ultraviolet light from the older eggs simply interfere with the embryogenesis process in the newer eggs; for example by disrupting the precise timing and coordination of events, needed to develop a healthy larva. This conclusion seems strengthened by the observation of frequent deformities developing in younger eggs after exposure to considerably older ones, in Burlakov's experiments. But what about the *positive* effect, when the development gap between the two groups is smaller?

Burlakov did not stop here, but introduced a further variation into the experiments, which threw simplistic interpretations out of the window. He inserted various *optical filters* between the quartz windows of the stacked containers. The results varied dramatically, according to which wavelengths of light were respectively blocked, or transmitted, by the filters.

Burlakov reported:

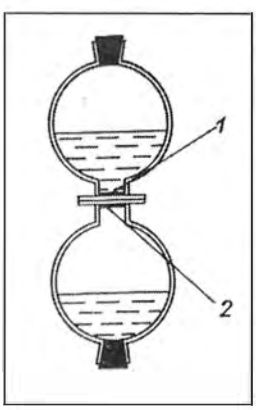
"All the filters which cut off the UV spectral part diminished the mortality rate of the younger embryos, without affecting the viability of the older groups. On the other hand, the development of the younger group embryos was considerably delayed, as compared with the control samples."

But on the other hand, he reported:

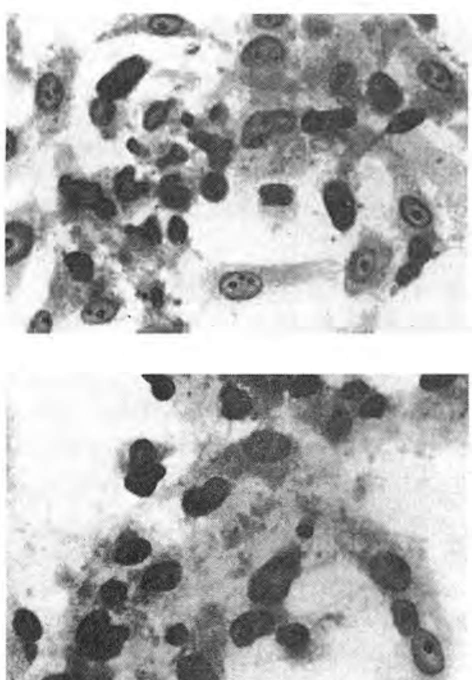
"All the yellow filters produced a *3-fold mortality increase in the* **OLDER** embryonic group, without affecting the viability of the younger group embryos. . . ." These striking results "require further exploration," he added.

In reporting his experiments to the Second Annual Gurwitsch Conference in Moscow late last year, Burlakov called attention to the work of Vlail P. Kaznacheyev and his group in the 1960s and 1970s, at the Siberian branch of the Soviet Academy of Medical Sciences. The experiments in question grew out of an early collaboration between Kaznacheyev and the legendary Pobisk Kuznetsov, on the implications of Gurwitsch's mitogenetic radiation. Kaznacheyev introduced cell cultures (liquid suspensions) of various animal and human cell types into identical, sealed spherical chambers fitted with quartz or glass windows. He fitted the chambers together pairwise, with the windows facing each other in contact, and mounted the pairs on a rotating vertical carousel in a constant-temperature room, in order to provide uniform conditions for the maintenance of the cells.

For selected pairs, Kaznacheyev infected the culture in *one* of the two chambers with a pathogenic virus, which caused



Drawing of two joined cell culture chambers connected by a glass or quartz plate. (1) is the zone of cell growth in a contaminated culture; (2) is the zone of cell growth in a control culture.



V.P. Kaznacheyev and L.P. Mihalova, Ultraweak Emissions in Intercellular Interactions (Novosibirsk: Nauka Publishers, 1981)

The upper frame shows chick embryo fibroblasts in a sealed chamber, which was contaminated with Coxsackie virus A-13. This chamber was connected by a quartz plate to another chamber containing uncontaminated chick embryo fibroblasts. After 48 hours, the same pathology was observed in the second chamber (lower frame).

the death of the infected cells within a predictable time. At various intervals, he removed selected pairs of chambers from the carousel and examined the cells of *both sides* under the microscope.

What did he find?

The cells in the infected chamber showed the expected, characteristic pathological effects of the virus. In a significant, but variable fraction of the experiments, Kaznacheyev also found a pattern of damage and death of the cells on the *other* side, even though there was no virus in that culture! The pattern and type of cell damage (cytopathic effect) in the noninfected cells, was *not* the same as on the infected side, but varied according to the type of virus and cell culture used.

Kaznacheyev called this the "mirror cytopathic effect." Apparently, some pathogenic influence is transmitted or induced from the infected and dying cells to the uninfected cells, by electromagnetic radiation alone (or, to put it perhaps more accurately, by an specific sort of electromagnetic "coupling" between the two cultures). Just as in Burlakov's later experiments, the "mirror cytopathic effect" disappeared, when ordinary glass windows were used instead of quartz ones.

Kaznacheyev did not stop with this "one-dimensional" sort of experiment, but added a crucial additional consideration: the influence of solar activity on the Earth's magnetic field during the course of the experiments. His attention to this point was based on a long history of investigation of the biological role of magnetic fields, and particularly the work of the geobiologist Alexander L. Chizhevsky (1897-1964).

Developing Vernadsky's hypothesis, that "life is a function of the biosphere," and, more broadly, of the solar system as a whole, Chizhevsky had carried out extensive studies of the correlations between the frequency and severity of outbreaks of major epidemic diseases, on the one side, and the cycles of solar activity and variations in the Earth's magnetic field, on the other. The strong correlations, demonstrated by A.L. Chizhevsky, were corroborated by investigations of changes in the rates of growth and mutation, virulence, and other characteristics of bacteria and other microorganisms, in connection with geomagnetic and solar-magnetic cycles and more short-term magnetic disturbances—the so-called magnetic storms. This work played an important role in the development of "magnetobiology," including the use of artificially generated magnetic fields, especially pulsed or "modulated" ones, for the treatment of disease and injuries.

(Remember, this whole area of "geomagnetobiology" grew out of Gauss and Weber's demonstration of the new physical principle behind Ampère's "angular force"; as well as Gauss, Weber, and Alexander von Humboldt's founding of the *Magnetischer Verein,* which organized the first coordinated, global measurements of the Earth's magnetic field and its variation in time.)

With this in mind, Kaznacheyev conducted a long series of double-chamber experiments—with more than 10,000 chambers!—continuously over the period 1966-1976, thus covering nearly an entire 11-year solar period. He also made simultaneous experiments in two different locations, in Novosibirsk and in Norilsk, near the Arctic Circle. Kaznacheyev found strong correlations between the relative incidence of clearly manifested "mirror cytopathic effects," and changes in the parameters of the local magnetic field and solar magnetic activity. Under certain geomagnetic conditions, the "mirror" effect nearly disappeared entirely, while in others it was heightened.

Unfortunately, Kaznacheyev's work came under heavy attack in the Soviet Union, and he did not develop his discoveries further.

Courtesy of Vladimir Voeikov

Alexander Leonidovich Chizhevsky (1897-1964) studied the effects of dynamic solar activity upon the biosphere, human health, behavior, and activities. He aslo discovered the vital effects of negative ions in the air for all animals. He was a close friend and follower of Konstantin Tsiolkovsky, the first to suggest the use of reactive engines for space flight.

A New Biophysics

It should not be surprising, that the revival of this direction of work, which actually goes back to Kepler, Leibniz, Gauss, Riemann, and Pasteur, is stirring up a storm today. There is no way to reconcile the experimental results sketched here, and many others, with "standard theories" either of molecular biology or of physics. Taken together with the work of Vernadsky and others in related directions, these results point to a new physical, or I would rather say, *biophysical* principle, of enormous importance for the future of the human race.

But the new principle itself has not yet been rigorously demonstrated. We are in a situation, perhaps comparable to that which followed Ampère's experimental demonstration of the "angular force"—before Gauss and Weber came along. To do for the anomalies of Gurwitsch, Kaznacheyev, Burlakov et al, what Gauss and Weber did for Ampère's demonstration, is the task we have set ourselves. To take that on, however, we must first rethink the whole matter from the standpoint of Kepler and Leibniz's method of *analysis situs.* We shall learn why, and how, in the coming installments of this series.

Jonathan Tennenbaum, who heads the Fusion Energy Foundation in Europe, is based in Germany.

Notes

1. Dino De Paoli, "Does Time Really Precede Existence? A Reflection on Prigoginism," *21st Century,* Spring 2000, p. 27.

U.S. Astronomers Engage in 'Dialogue of Civilizations' in Iran

by Marsha Freeman

When astronomer Alan Hale, the co-discoverer of the Hale-Bopp comet in 1995, read the comments by the newly elected Iranian President Mohammad Khatami, two years ago, calling for a "dialogue of civilizations" to improve relations between Iran and the United States, he thought that astronomy would be a natural opening for such a dialogue.

Hale knew that one of the best viewing sites for the last full solar eclipse of the millennium, in July 1999, would be in the ancient city of Esfahan, in central Iran, and so he contacted other astronomers, as well as former Apollo astronaut Russell Schweickart, and arranged an expedition to Iran in July 1999. The trip for the foreign visitors was arranged on the U.S. end through the group Search for Common Ground, and planned in Tehran by the Zirakzadeh Scientific Foundation.

When the Americans visited the ancient city of Esfahan, the Adib Astronomical Society, led by Alireza Mehrani, was their host. In addition to viewing the total solar eclipse with American and Iranian colleagues, Dr. Hale made well-received presentations about astronomy at several Iranian universities.

That initial trip to Iran was followed up in summer 2000 with a more ambitious program, hosted by the Adib Astronomical Society in Esfahan. It included the first gathering of Iranian Amateur Astronomy Groups, and also the Third Exhibition on Astronomy to be held in Esfahan. Hundreds of professionals, with a handful from a half-dozen foreign countries, participated in the technical conference presentations, and thousands of citizens came to the exhibition, to learn more about astronomy and space exploration.

Looking at Space, Together

Foreign guests gave three general speeches in the Exhibition Center, after each day's technical conference sessions. Dr. Hale presented an overview of astronomy, titled, "A Look Into Space." Dr. Charles Morris, from NASA's Goddard Space Flight Center, recounted "The 10 Greatest/Most Interesting Comets in the Past 30 Years," and a talk on "The Solar System," was presented by Ph.D. students Yaël Nazé and Francesco Lo Bue from Belgium. The audience was so enthusiastic, that the scientists were asked not only to answer questions about their presentations, but to give their autographs! In addition to the Americans and Belgians, scientists also attended from Germany and Singapore.

Adib Astronomical Society

Astronomer Alan Hale: "We look at the same sky at night. It doesn't matter where we are looking from. We see the same universe. We see the same truth. . . ." Here, Hale is speaking at a public lecture on astronomy during the international comet conference, held in Esfahan, Iran in July 2000.

This summer's conference in Esfahan, which focussed on a discussion of comets, was held July 22-24, in order to coincide with the visibility of Comet LINEAR in the night sky. The comet was discovered last year, and July was expected to be its brightest appearance (although ultimately, the scientists were disappointed with its celestial presentation).

The goal of the conference, according to Dr. Hale, was not only to take advantage of an astronomical opportunity. "It is the wish of all the participants in this endeavor, both American and Iranian," he wrote before the trip, "that this conference will help in fostering greater international scientific collaborations and in bringing all the peoples of planet Earth closer together."

One of the participants in Iran this year was former Space Shuttle astronaut Bruce McCandless, who is familiar to many from photographs of him

Adib Astronomical Society

At the booth describing general astronomy data are amateur astronomers (from left) Batool Ansari, Naeimeh Meshkani, and Narges Ansari. Thousands of interested citizens, many of them children, came to the exhibition hall.

floating free in space in the 1980s, testing NASA's Manned Maneuvering Unit. Dr. McCandless, who was also on the 1990 Shuttle mission that deployed the Hubble Space Telescope, provided audiences with a thrilling audiovisual presentation of space exploration.

Many of the foreign participants commented after the trip that Iran surprised them in many ways, one of them being the large number of women who have access to advanced education, and who attended the astronomy conference. An anecdote suggesting how quickly the nation is changing, related seeing a woman in a traditional black chador, talking on a cellular phone.

Some visitors reported meeting Iranians who told them it was good to have Americans back, after 20 years.

The same kind of optimism was expressed by the Iranian officials whose remarks to the conference were reported by the Adib Astronomical Society. The secretary of the Society, Alireza Mehrani, made an opening statement describing the meeting as a "manifestation of the global credo of negotiations among cultures and civilizations." He stressed the importance of "distributing this attractive science among the youth."

As Dr. Hale summed up the spirit of the conference: "We look at the same sky at night. It doesn't matter where we are looking from. We see the same universe. We see the same truth. . . ."

The Next Step

Many areas of potential collaboration with Iranian colleagues were noted by Dr. Hale. "With the Internet and remote-controlled telescopic operations," he believes, "there are some intriguing possibilities opened up by the fact that Iran and the United States are close to 12 hours apart; when it is day here it is night there, and vice versa." Thus, real-time nighttime observations on one side of the world could be used by the other side during daytime working hours.

Asked what he thought the next step should be in this informal U.S.-Iran science collaboration, former astronaut McCandless replied, "I would think the next step would be to bring some Iranians to the United States. It would be nice if some of them could come over and learn about astronomical space techniques, and maybe see a Space Shuttle."

Alan Hale believes that even though there is "still a significant amount of distrust between the two governments, President Khatami is serious in his publicly stated wishes to open up dialogue with the United States, even though he faces quite a bit of opposition from other factions in the Iranian government." Dr. Hale hopes there will be a summit between the heads of state of the two countries in the near future.

Yaël Nazé and Francesco Lo Bue

Developments and the techniques used in radio astronomy are explained by Nima Hooshmand at the astronomy exhibition.

INTERVIEW WITH ALIREZA MEHRANI

Bridging Cultures Via Astronomy

Dr. Alan Hale

Alireza Mehrani, seen here with his family in Esfahan, is an accountant with the city government and directs the 1,100-strong Adib Astronomical Society. He worked with Alan Hale to organize the international comet conference.

Marsha Freeman interviewed Mr. Mehrani, head of the Adib Astronomical Society of Esfahan, in November.

Question: Why was the comet conference this past summer held in the city of Esfahan?

The Adib Astronomical Society, a branch of the Esfahan Municipality, is the best-equipped amateur society in Iran, and perhaps in the Middle East. Because of its performance, the Society has been able to attract 1,100 members.

Those members, as well as the support given by City Hall, motivated us to establish such a gathering, in order to promote astronomy in the country. There are also physics and astronomy departments, on the Bachelors of Science level, in two of the major universities in Esfahan.

Question: How were the American and other foreign guests received by the officials, and the people of Iran?

There is no doubt that the first trip, in 1999, was enthusiastic for both the visiting delegation and the host. Both sides were worried about unpredicted issues. However, there was no reason to be worried during the second conference. The guests were able to establish scientific relations, and contact with the citizens. They were most welcome by the citizens, especially, the young.

Question: One of the important purposes of the conference was to bring together the many amateur astronomy groups throughout your country. How many people participated? Do you have any future plans?

About 30 representatives of Iranian amateur astronomy groups participated in the conference. There are thousands of people interested in astronomy, who come together in hundreds of astronomy groups throughout the country. We have a serious problem, and that is, that we don't know exactly where they are. The lack of communication among the groups, in this vast country, had caused these groups to remain unknown to us.

At the end of the conference in Esfahan, we had a meeting with all of the representatives, and we discussed how each group had to support the smaller groups in its own region. After the conference, two astronomy exhibitions were established, in Shiraz and Sabzevar, and we consider this an outcome of our conference.

Question: You mentioned in your report on the conference, that in addition to the technical presentations there were public lectures and an exhibition, which were attended by thousands of people. What was the impact of this activity?

Most of the visitors in the exhibition were high school and university students. Many of them established regular contact with the Society after the exhibition in order to promote their understanding in this field.

Despite the fact that, according to our culture, Iranian parents are not interested in letting their children, especially the girls, stay outdoors at night, the effect of the exhibition made them let their children stay in out with our Society at night in order to observe the sky. There was another reason for this positive result: Astronomy is a safe recreational activity, in addition to being a scientific field for the students.

Religious beliefs are also an important factor for our people being more interested in astronomy, because our holy Koran invites people to think about the creation and sky and the Earth, in several places.

People's visits with the participants were interesting for two reasons: first, because of the American nationality of the participants, and second, for their scientific background. People wanted to have the autographs of the participants, and to take their pictures with them.

Question: You said in your opening remarks to the conference that this scientific gathering was "a manifestation of the global credo of negotiations among cultures and civilizations." What is the role that scientists can play in this regard?

Although the conference was on astronomy, the additional programs helped the participants learn more about our culture and people. If such trips do not take place, people's thoughts may remain based on some past illusions, which may not be based on reality.

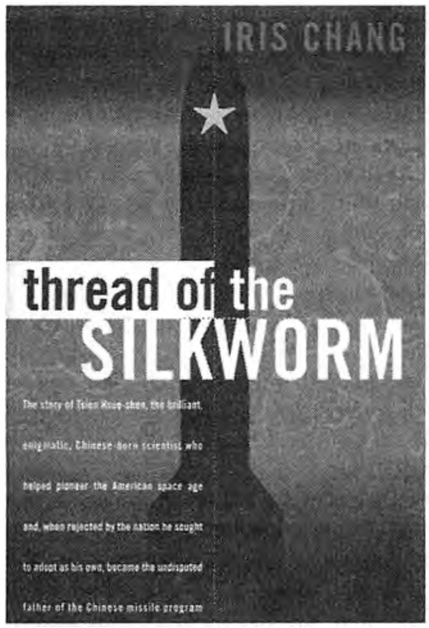
As for the two nations of Iran and the U.S.A., the point is more important. The continuation of such trips can provide the possibility for negotiations in all fields.

BEFORE WEN HO LEE

Tsien Hsue-shen: Father of China's Rocket Program

by Glenn Mesaros

The Thread of the Silkworm
Iris Chang
New York: Basic Books, 1995
Hardcover, 329 pages, $27.50



On Oct. 16, 1964, the postwar Pax Anglo-Americana was shattered by the explosion of the first Chinese nuclear bomb, in the western desert over Lop Nor, not far from the legendary Silk Road. The 20th century "backward" Chinese (who actually were the ones to invent rockets), it appeared, had now caught up with the West.

President Lyndon Johnson's science advisor, who had forecast this development to occur on Oct. 1, the Chinese Communist Party Day, urged Americans "not to worry," as it was a "small bomb," and, after all, China had no delivery mechanism, which would take "years to develop."

Two years later, China became the first country to simultaneously test a nuclear missile and an atomic bomb, by launching the DF2A rocket with a 1,290-kilogram nuclear device. It traversed the western China deserts of Xinjiang province for 800 kilometers, exploding with 12 kilotons of force.

On Oct. 28, 1966, *The New York Times* revealed to many unwitting Americans that the "man responsible for putting Communist China's first atomic bomb on the nose of a missile was trained, nurtured, encouraged, lionized, paid, and trusted for 15 years in the United States." His name was Tsien Hsue-shen, the director of China's missile and nuclear program.

Tsien Hsue-shen, which means "study to be wise," was born on Dec. 11, 1911, in Hangzhou, not far from Shanghai. He was a direct descendant of the 10th century Wuyue emperor, Qian Liu. During that same month, Dr. Sun Yat-sen became the first president of the new Republic of China.

As a privileged child of nobility, Tsien received a classical education in elementary school, and was then sent to the "city of bookworms," Beijing, for middle and high school. He played the violin, and excelled in "nature diaries," wherein he placed flowers as substitutes for certain words. However, he was a mathematic prodigy, and wanted to become a scientist.

Tsien grew up during tumultuous times in China. As early as the British Opium Wars in the 1830s, China had been the object of colonial designs. The British maneuverings to counter the Sino-Russian alliance that had coalesced around linking the two nations through the Trans-Siberian Railway, had created the Boxer Rebellion in 1901. After the suppression of the Rebellion, the Western allies extracted "indemnities" from China, for damaging their own country! Because it was inexperienced in such colonial looting schemes, the United States turned its share of the indemnities into "Boxer" scholarships for Chinese students, to study in the United States.

Tsien studied hard at Shanghai's Jiatong University, which featured American engineering programs, taught in English. By 1932, Japan had already bombed Shanghai, in the prelude to World War II, and civil war was under way in China, between the Guomintang Party led by Chiang Kai-shek and the Communist Party of Mao Zedong. Tsien obtained a Boxer Scholarship, and left China in 1935 for the Massachusetts Institute of Technology.

The Cal Tech 'Suicide Club'

He soon transferred to the new California Institute of Technology, where he became the protégé of Dr. Theodore von Kármán, director of the Guggenheim Aeronautical Laboratory. Von Kármán had also previously been a consultant to China's prestigious Tsinghua University, which had given Tsien his scholarship.

Tsien quickly became von Kármán's most brilliant protégé, who von Kármán described in his book, *The Wind and Beyond,* as having the "ability to visualize accurately the physical picture of natural phenomena." They jointly developed a "pressure correction formula" in the days before computers, using slide rules.

When not in von Kármán's rigorous classes, Tsien discovered a budding rocket scientist named Frank Malina, a fellow student, who idolized Leonardo Da Vinci, and considered himself a "renaissance man." They soon formed a five-man group of rocket enthusiasts, enamored of German scientist Hermann Oberth's new book, *Rocket into Interplanetary Space.*

When numerous of their rocket experiments dangerously failed, they became known as the "Suicide Club," and were banished from campus to a safer desert area, now the site of the Jet Propulsion Laboratory. The Suicide Club held riotous, informal parties, where discussion ranged from classical music to rocket science, interrupted by huge arguments, which resolved into gales of laughter. Malina and Tsien were also inseparable attendees at all of the concerts of the Los Angeles Philharmonic Orchestra.

Meanwhile, the Great Depression raged, and political discussion proliferated around Cal Tech, including informal "bull" sessions, of what later were alleged to be "meetings" of the Communist Party. Tsien and Malina attended these meetings as a common event of the time.

From Student to Colonel

Like most American scientists, they wanted their research to be used to defeat fascism. General Hap Arnold transformed the Suicide Club into a formidably financed rocket weapons testing elite. In August 1941, they launched their first JATO (jet assisted take-off) airplane. By 1944, they had launched a missile to an altitude of 14,500 feet.

At the end of World War II, Tsien had obtained a gold badge security clearance, and a rank of colonel in the Army Air Corps, as a chief scientist. He was given an official commendation by the Office of Scientific Research and Development, and by the director of the rocket section of the National Defense Advisory Board.

The Army rushed him to Europe after VE-Day, to help interrogate top rocket scientists, one of whom was Wernher von Braun. The German scientists revealed to him that they had tested his published theories in their supersonic wind tunnels.

Returning to the United States, Tsien became one of the youngest tenured full professors in the history of MIT, at age 37. He was soon offered, and accepted, the directorship of a research center at Cal Tech, where he became the Goddard Professor of Jet Propulsion.

When he applied for U.S. citizenship in 1949, *Time* magazine featured Tsien proposing a coast-to-coast rocket airliner. In December of that year, he addressed an American Rocket Society meeting in New York, where his proposal for being able to travel to the Moon in less than 30 years became the basis for the drawing of astronauts on the cover of *Popular Mechanics Magazine,* in May 1950.

But politics were about to intervene.

From Scientist to 'Spy'

On June 6, 1950, agents from the Federal Bureau of Investigation visited Tsien's office at Cal Tech. They informed him that the social gatherings at the Pasadena home of fellow scientist Sidney Weinbaum in the 1930s, were, in fact, meetings of Professional Unit 122 of the Communist Party. They said that Tsien's name had shown up on a 1938 prospective membership list, with the alias "John Decker."

The Soviets had detonated their first nuclear device in December 1949. The Communist Party of China had taken control of that nation. By May 1950, Alger Hiss had confessed to spying for the Russians, and Manhattan Project scientist Klaus Fuchs had given nuclear bomb secrets to the Russians. The Truman-McCarthy red scare now escalated, in order to destroy the last vestiges of President Franklin Roosevelt's postwar plans, based on engaging *both* Russia and China to end colonial rule around the globe.

That the aristocratic Tsien, who had married the daughter of one of Chiang Kai-shek's generals, could be a Communist was laughable to his students, and to his closest academic associates. However, the Army had already stripped him of his security clearance, which signalled the end of his pioneering rocket research.

Tsien was deeply insulted by such accusations and treatment, and unable to continue his work. He decided to return to China, despite the Communist regime, and he booked passage on a steamer for China for his wife and children, and for his voluminous research notes. The paranoia was such that Customs agents seized his logarithmic tables as "secret codes"!

What followed was a surrealistic five year legal conundrum around his case, in which he tried to leave, having been virtually accused of being a traitor, while U.S. government agencies refused to let him go to China, lest he share his work there; however, they were unable to prosecute him for any offense. When Tsien tried to stay in the United States, Customs agents started a hearing to deport him! Finally, he could do nothing but return to Cal Tech, until his case was resolved.

After five years in limbo, Tsien was allowed to be deported by the Eisenhower Administration. Former Undersecretary of the Navy, Dan Kimball, remarked during that time: "I'd rather shoot Tsien then let him

National Air and Space Museum, Smithsonian Institution

Tsien (right) on a secret U.S. mission at the end of World War II, to interrogate top German scientists for aerodynamics information. With him on the steps of the Kaiser Wilhelm Institute in Göttingen are (from right) Theodore von Kármán, Ludwig Prandtl, and Hugh Dryden.

leave the country. He knows too much that is valuable to us. He's worth five divisions anywhere." Years later, Kimball stated, "It was the stupidest thing this country ever did. He was no more a Communist than I was—and we forced him to go."

(This case must remind the reader of the recent debacle of fired Los Alamos National Laboratory scientist, of Chinese origin, Wen Ho Lee. Like Tsien, Lee has been presented with no evidence that he was a spy, but has been stripped of his clearance, fired, and disgraced. The demoralizing impact of this witchhunt has been felt throughout the national weapons research laboratories.)

In China, a Hero

When Tsien arrived back in China, he received a hero's welcome. He was immediately placed in charge of the primitive rocket program, along with fellow deported scientist Chao Chung-yao, and dozens of others. Tsien organized the program on a rigorous theoretical basis, urging all of his students to study American scientific journals.

Within 10 years, China had moved forward from copying a simple Russian version of the German V-2 rocket, to become the fifth nuclear power in the world. In 1970, China joined the small, elite club of spacefaring nations, by launching its first Earth-orbiting satellite.

Xin Hua News Agency

Tsien received the highest honor a scientist can achieve in the People's Republic of China, "State Scientist of Outstanding Contribution."

As one might expect, Tsien did not fare well under Chairman Mao's Great Leap Forward. The government tried to depose Tsien from his prestigious position in the scientific community, but Premier Zhou En Lai intervened to save China's top scientist from disgrace.

Under the post-Mao direction of the Chinese government, in the past two decades, Tsien Hsue-shen has regained his well-deserved stature as the father as the Chinese space program. His advice is sought by government leaders, and he is revered throughout the country.

Tsien has refused to allow any authorized biography of him to be written before his death. That accounts for the shortcomings of Iris Chang's work, which necessarily had to rely on secondary and tertiary sources, and, therefore, lacks the answers to many questions that Tsien alone could provide.

The Chinese space program is now poised to enter the exclusive company of the United States and Russia in sending men into space. Although no accomplishment the breadth and scope of space exploration could ever be the product of one man, like Wernher von Braun in the United States, and Sergei Korolev in Russia, Tsien Hsue-shen stands prominently as the father of China's military and civilian space programs.

A Case Study in the Racism of Anthropology

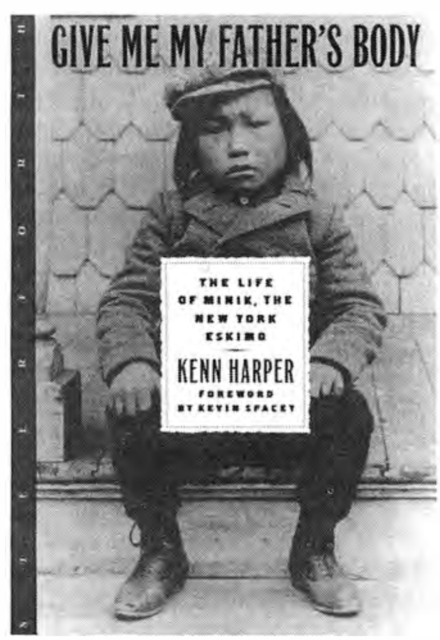
by Denise Henderson

Give Me My Father's Body: The Life of Minik, the New York Eskimo
Kenn Harper
(Foreword by Kevin Spacey)
South Royalton, Vt.: Steerforth Books, 2000
Hardcover, 277 pp., $24.00

Sometimes a book which focusses in on a slice of a larger picture, if done well, can provide an insight into the overall phenomenon of which it is a part. This is not the case with Kenn Harper's *Give Me My Father's Body,* which examines the fate of a group of six Eskimos brought to the United States by explorer William Peary.

Minik was an Eskimo boy, who at the age of six, along with five others, was brought from northern Greenland to the United States in 1897. It appears that Peary's only reason for doing so, was that his rival in attempting to reach the North Pole, the explorer Dr. Frederick Cook, had already brought back some human trophies to the United States. Peary himself had little interest in his human cargo, whom he promptly dropped off at the American Museum of Natural History, assuming that the Museum would somehow care for these living exhibits.

The 1890s was the era in which Jim Crow was in full force in America; people of color were treated as less than human. The American Museum of Natural History not only was no exception, but had an explicitly racist philosophy, from the top down. Its curator, Henry Osborne, believed that there were "superior" (Anglo-American), and inferior races (almost everyone else). Osborne's institutional outlook, was




"GIVE ME MY FATHER'S BODY!"

The Pathetic Story of [illegible] Esquimau Boy, Who Is Growing Up in New York and Is Going to Find the North Pole Some Day, but Who Now Wants Most the Bones of His Father from the Museum of Natural History.

From *Give Me My Father's Body*

The first newspaper article to describe Minik's attempt to have his father's body released from the American Museum of Natural History, published in The World, Jan. 6, 1907.


From *Give Me My Father's Body*

Minik and his foster brother, Willie Wallace, 1898.

expressed in the Museum's sponsorship of Teddy Roosevelt (who brought back animal trophies for the Museum), and expeditions like those of Cook and Peary (who brought back human trophies).

The author, Kenn Harper, misses this point. He does not understand, and therefore does not report, that *the Museum as an institution* was a promoter of a racist world outlook, which in the 20th century would lead it to sponsor conferences on eugenics (the human-engineering "cleansing" plans that preceded those of Hitler) in the 1930s, and to promote the sterilization of "inferior" African-Americans, poor whites, and "the criminal classes," as well as the retarded and the mentally ill.

The Story of Minik

Despite the book's limited view, the story it tells, written by someone who has lived in the Arctic for 30 years, is of interest. By 1898, Peary's Eskimos, who had been housed in the dank basement of the American Museum of Natural History, were beginning to die of pneumonia. Although they were moved into the country, five of the six soon died, leaving only the seven-year-old Minik.

Fortunately for Minik, William Wallace, a Museum employee who seems to have seen Minik as a human being, took him into his own household. Wallace and his wife cared for the boy throughout his youth and adolescence, as if he were their own son, even when the Museum refused to provide funds for it. For a while, when Wallace was still in the Museum's employ, Minik was raised in the healthy country air of Cobbleskill, New York, north of the city. In 1900, however, Wallace was accused of embezzling funds from the Museum (which may have been a convenient way of getting him out of the way). He and his family were forced to move to New York City, where Wallace worked on building the New York subway system.

Even with his reversal of fortune, Wallace continued to care for the boy, never viewing him as a burden. But Minik suffered renewed bouts of pneumonia, as he reached adolescence. He began to feel himself to be a burden to his adoptive father, and determined to return to Greenland. He finally was able to get passage on a ship in 1909. (The book title, by the way, refers to Minik's fight to retrieve his father's stuffed body, on display at the Museum, for proper burial in Greenland.)

Minik remained in Greenland for only seven years. He rapidly relearned the Eskimo ways, but was unhappy there. Although he proposed that educational programs be put in place to help his fellow Eskimos, he did not have the education himself to implement such programs. Because of his ongoing ill health, his education in the United States had been sporadic.

By 1916, after a failed marriage, and saying that he missed the bright lights of Broadway, Minik returned to the United States. In the fall of 1917, he heard about jobs available at a logging camp in Pittsburg, N.H. There, in the north-eastern corner of the state, among the French Canadians emigrating down from Canada, Minik spent a season as a logger.

He was then taken in by the Hall family, farmers who treated him as a member of their family. But when the great influenza epidemic broke out in 1918, at the end of World War I, Minik died of the flu, despite the best care the family could give him.

Ignoring the Obvious

This book has only recently been published in America. As far as this reviewer can ascertain, the main reason for doing so is because actor Kevin Spacey, who has written a foreword to the book, has taken out an option to turn the book into a movie. The root of the problem with the book lies not in the bare facts of Minik's story, but in the author's uninformed view of the the American Museum of Natural History and its anthropologists.

"It is simple to characterize these men as cold, unfeeling, dispassionate scientists who cared little for the human consequences of their work," Harper writes. "This stereotype of the early anthropologist is not borne out by fact. Most of these men did care. It was their interest in human beings that had drawn them to the science of anthropology in the first place. They and their colleagues in cultural anthropology— men such as Boas and Kroeber—were proud of their liberalism and open-mindedness. They would have been hurt deeply had anyone suggested that they were, at heart, racists."

Harper continues: "They were, nevertheless, products of their times, and the intellectual and cultural traditions from which they had emerged were permeated throughout with an insidious bigotry. The endemic prejudices of the late nineteenth century were racist and sexist. They determined that, to the anthropologist no less than to the man on the street, men were superior to women, and whites were superior to blacks. The Eskimos had inspired intense scientific and popular interest because they had been able to eke out a livelihood, and at the same time develop a rich culture, in the world's most hostile environment. They were remarkable, but they were not white, and that fact alone marked them too as inferior."

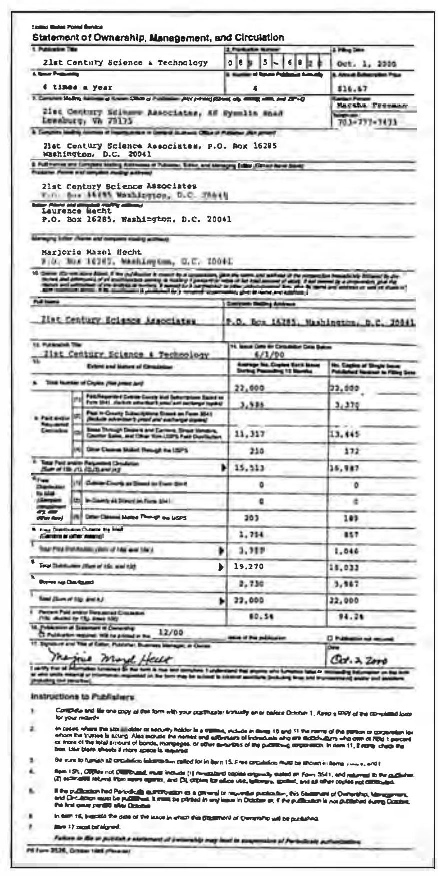
To the reader unfamiliar with the battles which had taken place in the United States much earlier—not to mention of course the battle against de facto slavery after the failure of Reconstruction and the rise of Jim Crow in this very period—this may seem like a fair statement of the case. But the truth is that anthropology was not a "science" in its infancy, but was developed as an oligarchical ideology that would demonstrate, through "cataloguing," that there were "inferior" and "superior" gradations of human beings.

Indeed, almost at the turn of the 19th century, at a meeting of the American Academy for the Advancement of Science, the issue of the unity of the human race had been fought out, and the defenders of the idea that there was only one human race had unfortunately lost among the academics, because too few of them were willing to stand up against the Southern ideologues. These were the Confederates who defended slavery on the grounds that African-Americans were inherently "children" who needed to be "cared for," and who could never grow up.

Thus, Harper's assertion about the infancy of anthropology and its blameless adoption of the "prejudices" of the day, is not an honest statement of the intense, in-depth battle going on, in the United States and abroad, to defend the humanity of all mankind.

Minik seems to have had a little sense of this battle. He himself talked about how he had lost all faith in Christianity—with the exception of his experience with Wallace and with his New Hampshire friends—as a result of his encounters with so-called Western civilization, which, of course, was actually his encounter with the American Museum of Natural History.

Unfortunately, today, the battle still remains. The Museum's anthropological exhibits still portray primitive peoples, reconstructed from bones, as having Negroid features—based on no real evidence—and the fight still rages about there being only one human race.



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Marjorie Mazel Hecht

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Marjorie Mazel Hecht — Oct. 2, 2000

Instructions to Publishers

Space Station

Continued from page 59

Shuttle crew of astronauts and cosmonauts in October, the stage was set for an historic moment in the history of space exploration.

A Gateway to the Stars

On Oct. 31, on the same Russian launch pad that nearly 40 years ago opened the space age to man, with the launch of Yuri Gagarin, Soyuz Commander Yuri Gidzenko, flight engineer Sergei Krikalev, and ISS Commander Bill Shepherd started their journey to the new station.

"You would hope that from this point on, we will never have a period when humans are not living in space. We'll learn to conquer low-Earth orbit—how to keep people alive [in space] for years at a time—and then on to the Moon, and on to Mars. And who knows where we can go from there."

These remarks by senior NASA space station project manager, Jim Van Laak, made on Nov. 2, when the first long-term Expedition 1 crew entered the International Space Station, were echoed by many of the two programs' managers, and astronauts and cosmonauts, and reflected the thoughts of the more than 100,000 workers who are part of the station's realization.

NASA

The Expedition 1 crew will live on the International Space Station for four months, carrying out a "shake-down" mission to install, test, and activate all of the station's operating systems. Here, an exuberant Sergei Krikalev, Yuri Gidzenko, and Bill Shepherd gather for a photograph, after having installed the Elektron oxygen generating system during the first week of their mission.

Inside the laboratories that the United States, Europe, and Japan will send to the station, experiments will be conducted to study the effects of microgravity on humans, animals, microbes, and plants. ISS researchers will observe both Earth and the cosmos. Materials science experiments will examine the new possibilities of creating new materials in space, and understanding the fundamental processes of physics and chemistry.

Hundreds of scientists from around the world will have remote access to new research facilities in space. Dozens more countries will have the opportunity to join in this great adventure. Young people are being inspired by this great project, as they watch it come into being.

The International Space Station is the most challenging and complex engineering task ever undertaken. It will require that all of the nations involved stay the course, through inevitable equipment failures, cost overruns, budgetary problems, and criticism.

But the station is now open for business. And the promise and potential of this emerging first city in space opens the door to creating the first true space-faring civilization.

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For complete information on how to submit abstracts, please see the IAF Web site at

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In This Issue:

VERNADSKY AND THE SCIENCE OF THE NOOSPHERE

Contrary to the Green-tinged versions of holistic biology, Russian biogeochemist Vladimir Vernadsky, pioneer of the term *biosphere,* saw the human mind as the highest development of natural processes. Categorizing this new stage of evolutionary development as the *noosphere,* he envisioned the extension of human mind over the Earth and into space.

In this issue, we present the first complete English translation of Vernadsky's revolutionary 1938 writing, in which he proposes that the space governed by living matter is of a Riemannian type. In an introductory editorial, Scientific Advisory Board member Jonathan Tennenbaum shows how the breakthrough in the science of physical economy achieved by Lyndon H. LaRouche, resolves an unanswered aspect of Vernadsky's work, developing more fully the concept of a multiply extended Riemannian manifold.

In a related feature article, Associate Editor Marsha Freeman examines the latest work on the terraforming of Mars.

In artist Michael Carroll's illustration of a Mars made habitable by terraforming, water developed by man would drain to the northern plains of the planet, creating an ocean that would cover up to 25 percent of Mars.

Courtesy of Michael Carroll