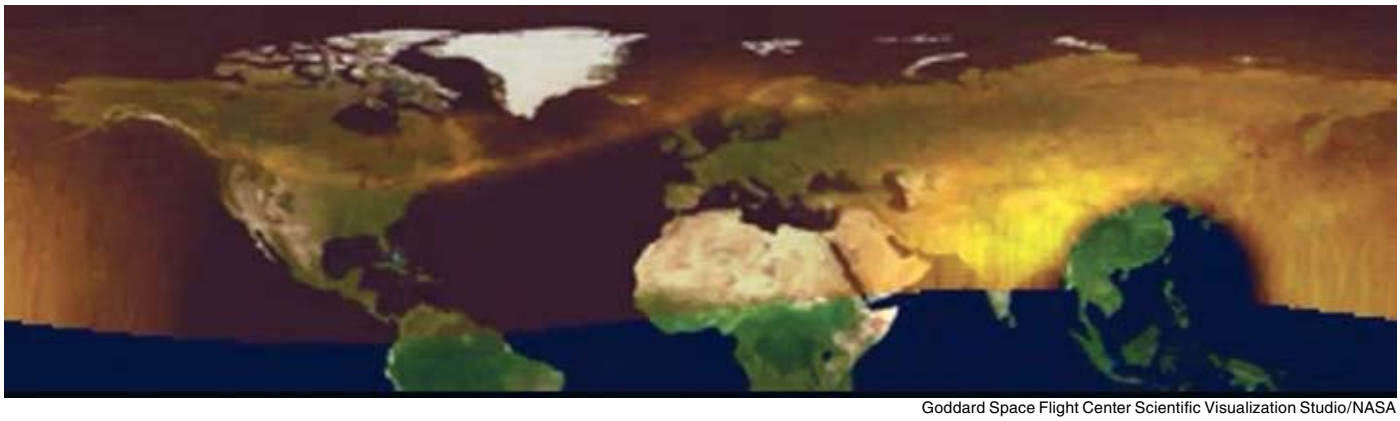


Goddard Space Flight Center Scientific Visualization Studio/NASA

Charged particles flowing outward from the Sun and hitting the Earth's magnetic field, emit light when they collide with atmospheric molecules. This visualization of the aurora over the North Pole was taken by the ultraviolet VIS Earth Camera on the POLAR spacecraft, on April 17, 1999.

ONWARD TO MARS

The Triumph of The Weak Forces

by Oyang Teng

Because of the limitations of our sense organs, we are conscious only of a narrow sliver of the electromagnetic spectrum, mostly in the range of visible light and infrared radiation. While other organisms are adapted to sense different regions of the spectrum, we rely on the use of our extended "technological sense organs" to gain access to the full range of radiation penetrating the terrestrial environment from the Sun and more distant cosmic sources, as well as their interaction with the atmosphere and electromagnetic fields of the Earth.

With this expanded sense apparatus provided by instrumentation, we can thus see not merely discrete objects existing in empty space, but an active continuum extending within and between all such seemingly separate objects, composed of both the presumed particles of cosmic rays, as well as the various, intersecting electromagnetic wave-phenomena.

In this way, we continually overcome the very real limitations of our physiology, although we remain susceptible to artificial limitations in our thinking—particularly when we allow a naive interpretation of our basic sense perceptions to dominate our picture of the physical world, whose characteristics in the very large and the very small are revealed by the general phenomena of cosmic radiation.

The Russian biogeochemist Vladimir Vernadsky believed that the pervasive action of the continual range of the unseen cosmic radiations permeating all of space was so significant, that not only the biosphere—including its transformation by human action into the noösphere—but even the distribution and character of the chemical elements in the crust, could only be understood as manifestations of cosmic processes. In *The Biosphere,* he wrote that living organisms are "the fruit of extended, complex processes, and are an essential part of a harmonious cosmic mechanism, in which it is known that fixed laws apply and chance does not exist."

Meeting the challenges of a manned Moon-Mars mission will open the entire electronmagnetic spectrum for human use, redefining cognitive science for the next century.

Like Poe's purloined letter, the evidence for the "harmonious cosmic mechanism" is all around us. The vast experimental data on cosmic radiation and its connection to cycles of climate, biodiversity, and mass extinctions are substantial, albeit preliminary, hints at the effects of biological regulation at an

astrophysical scale.[1] A rich material-energetic connection binds the Earth with the Solar System and the entire galaxy.

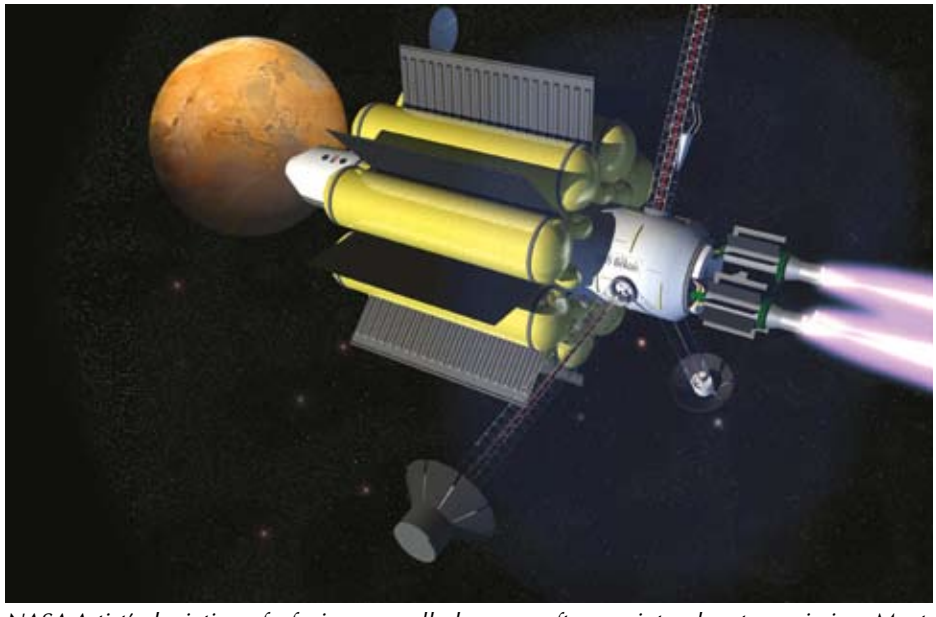
Just as important as this *connection,* is the material-energetic *distinction* manifested among non-living, living, and cognitive processes. As the highest expression of material-energetic transformation, both the biosphere as a whole, as well as individual organisms (the specific expression of what Vernadsky called living matter) provide natural instruments of the most exquisite sensitivity for registering the fundamental properties of material and energetic phenomena. Rather than attempting to build the universe up from its presumed smallest, inorganic parts, we must build downwards from cognitive and living processes. This approach will necessarily lead to, among other things, an expansion of the Periodic Table of the Elements.[2]

Unfortunately, the much-hyped historical division between the mechanistic and vitalistic outlook, has ingrained a false dichotomy in contemporary thought. For example, although the mechanist reduces all processes, including biological ones, to movements of discrete particles of matter, and the vitalist locates causality in some agency acting outside those material parts, typically in some unique form of "energy," both accept the same fundamental assumption regarding the existence of discrete particles of matter as such. Despite the fact that few people today would claim to be either true mechanists or true vitalists, modern science is still shackled by a crude materialism, continued, for example, in the form of the compromise known as the wave-particle duality.

How does scientific thought distinguish the efficient existence of discrete, whole processes from the physical continua in which they participate? For example, the Earth's biosphere as a whole represents a singularity within the constant biogenic migration of atoms throughout the galaxy, just as individual organisms represent singularities within the process of biogenic migration through the biosphere.[3] Do these singularities represent unique manifestations of physical space-time, as Vernadsky hypothesized?

If so, it makes clear the revolutionary implications of interplanetary spaceflight at accelerations sufficient to produce an artificial gravitational field, as contained in the Moon-Mars colonization proposal of Lyndon LaRouche. The consideration of living processes within accelerated reference frames amidst the dense radiation fields of cosmic space goes to the heart of the fundamental questions at the root of a true, Unified Field Theory.[4] Although the theoretical questions involved are fascinating in themselves, human progress depends on their answer by direct experiment—which a rapid development of helium-3-powered fusion rockets could easily make possible within this century, and perhaps even within decades.

However, there already exists a vast record of experimental evidence pointing to the unique physical space-time attributes of living organisms, including the biological significance of electromagnetic radiation.



NASA Artist's depiction of a fusion-propelled spacecraft on an interplanetary mission. Meeting the challenge of how to enable human beings to withstand the dense radiation fields of cosmic space will have revolutionary implications for our understanding of the biosphere.

Aside from more energetic biochemical reactions, organisms are highly sensitive to forces operating at apparently much lower orders of magnitude. Such weak forces prominently include low-intensity electromagnetic radiation, producing so-called "non-thermal" effects; that is, operating below those intensities capable of heating or noticeably disrupting living tissue. These effects have been extensively documented, despite historical opposition to the orthodox view of the organism as nothing more than a biochemical machine governed by point-to-point interactions in the small. Typical of such prejudice, is the Linear No-Threshold theory, which declares any amount of ionizing radiation as biologically damaging, despite the overwhelming evidence for the benefits of low-dose radiation.

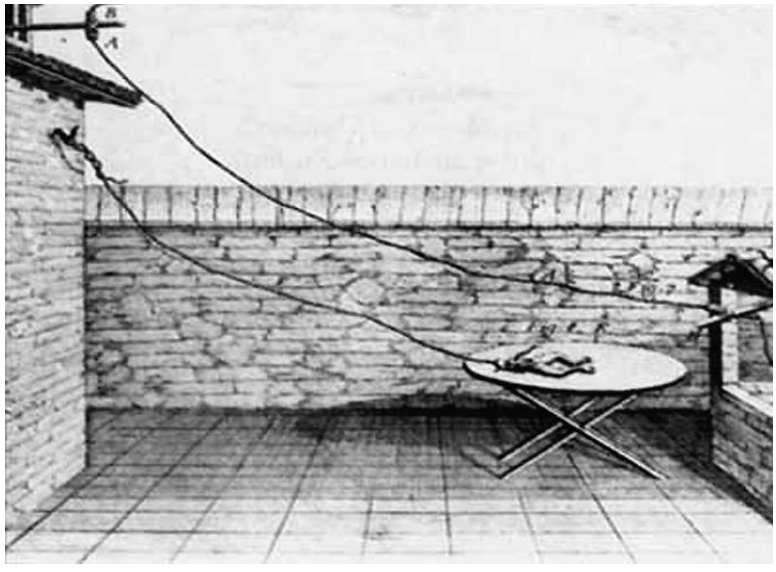
Vernadsky's definition of an individual organism as inseparable in principle from the entire biosphere, and, by extension,

1. Sky Shields, "Kesha Rogers Victory Launches the Rebirth of a Mars Colonization Policy!," this issue, p. 8.

2. Peter Martinson, "Towards a New Periodic Table of Cosmic Radiation," this issue, p. 18.

3. Shields, see Note 1.

4. Sky Shields, "The Significance of Biological Research in Space for the Development of a Unified Field Theory," Submission to the National Research Council's Decadal Survey for Biological and Physical Sciences in Space, October 2009. http://www8.nationalacademies.org/SSBSurvey/DetailFileDisplay.aspx?id=399.



Luigi Galvani (1737-1798) was experimenting with static electricity and a dissected frog, when a metal tool touched an exposed frog nerve, causing the dead frog's leg to kick, thus initiating a study of electromagnetism and life.

from the cosmic processes which produced it, demands a new understanding of the organism as, essentially, a uniquely organized electromagnetic process. However, this should not imply the New Age vitalism of "life energies" or similar mysticism. Similarly, some investigators in the field of bioelectromagnetism, professing to reject the limitations of a traditional mechanistic view, have relied instead on a cybernetic interpretation of self-organizing phenomena in life, despite the fact that the living processes they study are *in principle* irreducible to cybernetic concepts such as feedback loops and information theory, derived entirely from the operation of machines.

The Body Electric

As we shall see, confronting the challenges of a manned Mars mission today offers the most lawful means for deepening our understanding of the relationship of electromagnetism to life, a subject of investigation which goes at least as far back as the famous 18th Century experiments by Luigi Galvani on the electrical stimulation of frog legs. The field of study now includes everything from the bioelectric organs used by sharks to hunt their prey, to the nature of electrical regulation of the human brain and nervous system, to the internal magnetic compasses of birds and fish. One of the most dramatic manifestations of electromagnetic regulation in organisms is the phenomenon of regeneration, the re-creation of fully functional body parts which are lost because of injury, the study of which led scientists like Robert Becker[5] to

5. Robert O. Becker and Gary Seldon, *The Body Electric: Electromagnetism and the Foundation of Life* (New York: William Morrow and Company, 1985).

The planarian, a primitive flatworm, can regenerate the whole organism from almost any piece of itself that is cut off. Internal electromagnetic currents determine positioning.

This sea star is growing new legs.

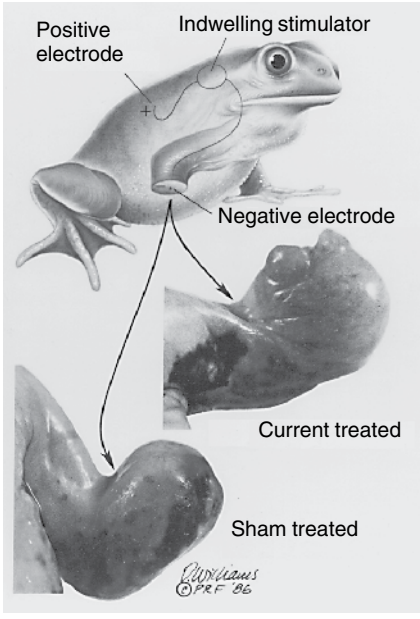
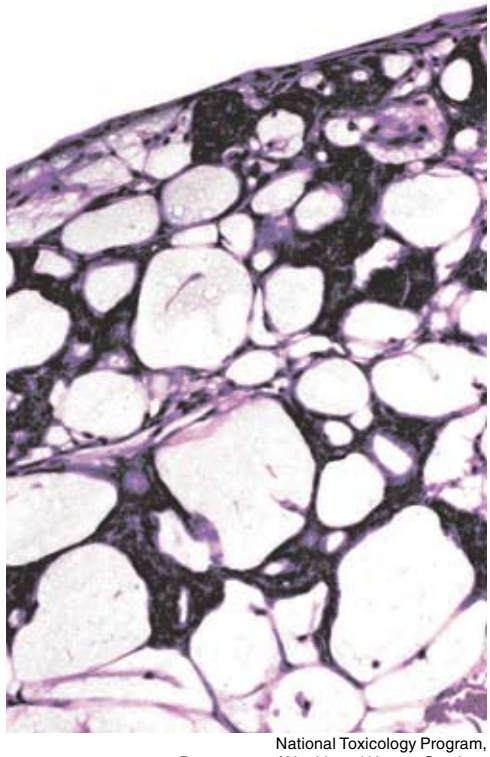


Figure 1
ELECTRICAL STIMULATION OF FORELIMB REGENERATION IN ADULT FROGS

The negative electrode is routed into the limb stump tip, and the positive electrode under the skin of the back, as depicted in the drawing of the frog (top). The photographs below the drawing show actual responses of current-treated and sham-treated limbs. The arrows point to the plane of amputation in the limbs.

Source: R. Borgens, *J. Exp. Zool.*, Vol. 200, pp. 403-416. Reprinted by permission of Wiley-Liss, Inc.



National Toxicology Program, Department of Health and Human Services

Image of blastema cells, a mass of cells at the stump tip from which the new limb eventually forms. Surrounding the blastema are clear cystic spaces.

begin the systematic investigation of the relationship between electromagnetism and living systems.

Measurements made in the 1830s first established that small electrical currents are produced around injured tissue in animals. Where does this electricity come from? The discovery of the nerve action potential not long afterwards seemed to solve the mystery, by attributing bioelectrical potentials to the differences in ion concentrations across cell membranes. However, later experiments demonstrated that, although the emergence of direct electrical currents depended on the presence of peripheral nerve tissue, they were not merely secondary effects of the action potential. These direct currents exhibit very distinct behavior during regeneration, a capacity which becomes more prevalent in organisms the lower down the evolutionary ladder one goes. For example, the planarian, a species of flatworm with a primitive nervous system, can regenerate whole organisms from almost any piece of itself that is cut off! Experiments showed that the head-tail axis of the planarian was determined by electric poles established by internal currents, and that artificially reversing the direction of current could produce a head where a tail would normally be found, and vice versa.

However, it was the study of salamanders which first revealed the highly specific behavior of the currents of regeneration. In amputated salamander limbs, the injury current was found to reverse direction a short time after injury, going from positive to highly negative. This reversal in polarity, combined with an increase in its magnitude, is accompanied by the formation of a mass of cells at the stump tip, called the blastema, from which the new limb eventually forms. As regeneration proceeds, the magnitude of the polarity slowly diminishes, eventually returning to zero. In non-regenerating animals like frogs and even rats, partial regeneration can be induced by mimicking these highly specific polarity and magnitude changes with applied electric current.

The blastema itself turns out to be adult cells that have de-differentiated into a totipotent state, capable of re-differentiating into the needed new types of cells required by the regenerating limb. So, in addition to the question of the origin of the electrical currents, we must ask: How is it that such currents are capable of initiating the process of blastema formation by inducing specific cells to de-differentiate, and how do they help to determine the form of the regenerated body part? "All the experiments led to one unifying conclusion: The overall structure, the shape, the pattern, of any animal is as real a part of its body as are its cells, heart, limbs, or teeth."[6]

What role does electricity play in "remembering" the whole organism, even when the physical parts disappear?

In humans, the closest analogue to regeneration (as distinct from wound healing) is the repair of bone fractures, which is accompanied by the formation of a blastema and the characteristic polarity and magnitude reversals of the injury current in regenerating limbs, and which has been found to be accelerated through the application of pulsed electromagnetic fields. The electromagnetic control system for the body as a whole extends from the brain throughout the nervous system and, among other things, regulates the overall activity and sensitivity of the brain's neurons—although the seemingly unlimited capacity for the brain to reorganize itself, generally termed

6. Becker and Seldon, see Note 5.

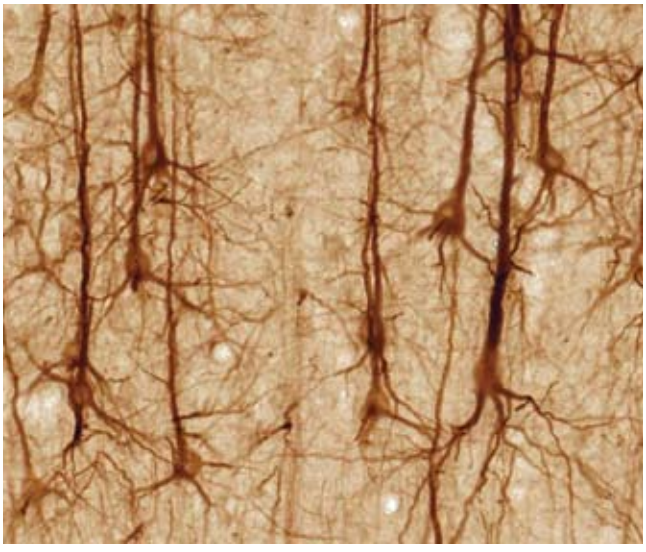


Image of neurons in the brain. In the human, the electromagnetic control system regulates the whole body, including the activity and sensitivity of the brain's neurons.

German biologist Hans Driesch (1867-1941) pioneered experiments showing that each individual cell is dependent on its relationship to every other cell in the developing embryo.

neuroplasticity, seems to defy any simply biological or bioelectric explanation.

Then again, explanations for many of the most basic processes of biology have proved elusive. For example, the formation of the blastema in regeneration is strikingly similar to embryogenesis, the intricate and highly coordinated processes governing the action by which a full organism develops from a single, undifferentiated germ cell.[7]

Northwestern University Prof. Günter Albrecht-Bühler.

It is now known that weak electrical currents play a significant role in the formation of the embryo, and just as in regeneration, exhibit highly specific forms of behavior.[8] Experiments on chick embryos showed that artificially manipulating the current in one part of the embryo leads to significant changes in the whole, indicating that the electric field's primary function is not limited to governing local cell migrations, but rather in helping to direct differentiation throughout the entire embryo. The pioneering experiments of Hans Driesch at the end of the 19th Century had already established that an individual cell's fate is dependent on its relationship to every other cell in the developing embryo, a seeming total dependence of the part on some pre-existing whole. Alexander Spemann's work not long afterwards showed that the interplay between part and whole was more complex, as certain groups of embryonic cells, which he called "organizers," could determine the fate of neighboring cells.

What means do cells possess to interpret their position within the whole, so important for differentiation? Northwestern University researcher Günter Albrecht-Bühler has shown that cells can emit and detect light pulses in the near infrared range, a kind of cellular sight which

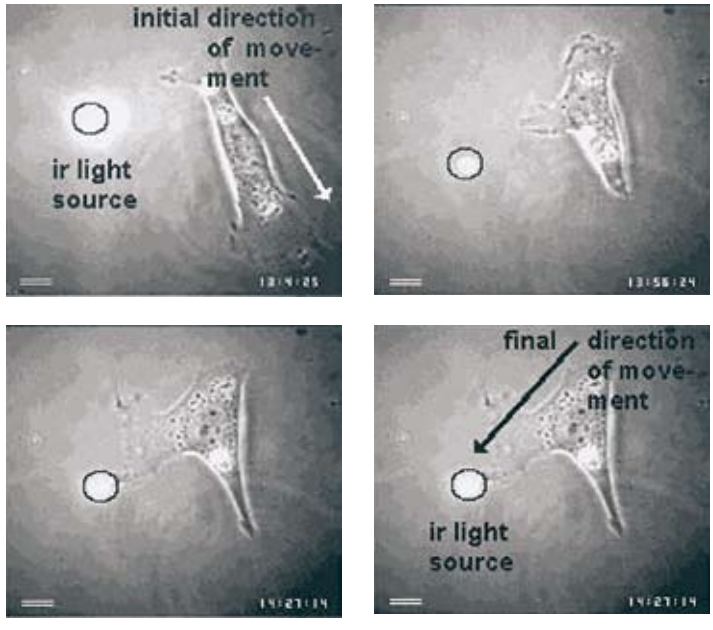


Figure 2
CELLS RESPONDING TO NEAR INFRARED LIGHT

Günter Albrecht-Bühler's work shows that cells use centrioles to "see" all objects around them that emit or scatter near infrared light. This is from Albrecht-Bühler's website on "cell intelligence." www.basic.northwestern.edu/g-buehler/FRAME.HTM

Source: Courtesy of Günter Albrecht-Bühler

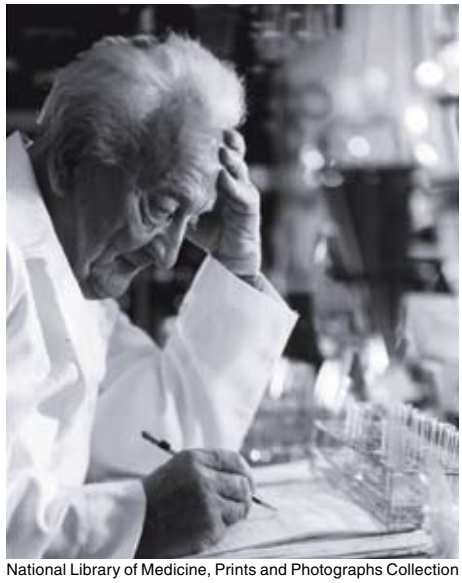
7. There also appears to be an interesting relationship between regeneration and cancer. Becker reports on the work of Meryl Rose, who demonstrated in 1948 that salamanders infected with cancerous growths could be cured by amputating a limb and inducing regeneration, implying that regeneration's guidance system could control cancer, and underscoring that the state of the entire nervous system can affect cancer.

8. Colin Lowry, "The Electric Embryo: How Electric Fields Mold the Embyo's Growth Pattern and Shape," *21st Century,* Spring 1999, pp. 56-70.

causes different types of cells to respond in different ways to the same signal. Other experiments established that different cell types also respond in distinctive ways to an electric field. Combined with Alexander Gurwitsch's 1920s discovery of mitogenetic radiation in the ultraviolet range, a biophotonic communication process governing mitosis, there appears to be a highly differentiated electromagnetic communication and control system already evident in the earliest stages of an organism's life.

In the chick embryo experiments noted above, different, asymmetric electric fields were produced by different parts of the developing embryo. When the internal field of one, but not the other, was artificially disrupted, a pseudoembryo developed, possessing the correct, basic external bodily form, but whose internal tissue was an undifferentiated mess. An analogous situation occurred in the formation of pseudolimbs in experiments on artificial regeneration. In these cases, the external form of the organism was not simply the end result of internal tissue differentiation, but seemed to have an independent existence, closely related to the action of the electrical fields. Again, how are these fields generated? And how do they help any given cell know how, or if, to differentiate?

Alexander Gavrilovich Gurwitsch (1874-1950)



National Library of Medicine, Prints and Photographs Collection

Albert Szent-Györgyi (1893-1986), pictured here in 1955, was awarded the Nobel Prize in 1937 for his work on cellular respiration.

The Biological Field

The fact that organisms can generate unique fields that play such a significant role in morphology, as during embryogenesis and regeneration, lends strong support to the biological field theory of Gurwitsch, who developed the idea in conjunction with studies of the even weaker mitogenetic radiation detected during cell mitosis. While recognizing the necessity for an "invariant law" to describe the coordinated action of individual cells within the whole organism, he was careful not to limit the biological field to any particular energetic manifestation, but to leave open the possibility that it could be expressed by any of the known physical field phenomena, or yet undiscovered physical processes.

How might the direct bioelectrical currents be a manifestation of this biological field? Becker drew on the work of Albert Szent-Gyorgyi to hypothesize that these currents operated by a process analogous to semiconduction in solid-state materials. The highly ordered internal structure within and between cells could faciliate the movement of free electrons. Gurwitsch similarly proposed that the primary work of metabolic energy involved the maintainence of highly ordered "non-equilibrium molecular constellations" within the protoplasm-protein complex of cells, and that some of the mitogenetic radiation was connected with these structures. This may indicate one possible link between the highly quantized effects of mitogenetic radiation, and the direct current system operating throughout the whole organism.

Unlike Gurwitsch, others saw in the field concept a way to reduce biological processes to strictly physical ones, that the only difference between the living and non-living "is to be found in all probability in more complex fields and more complex molecular structure,"[9] rather than in the unbridgeable distinction of separate, but interacting, phase spaces. In this sense, the concept of field itself has been reduced to supposedly "real" particles of inorganic matter surrounded by fields,

> a remnant of old materialistic conceptions. As a matter of fact, insofar as "particles" are known to be fields and field-structures they fill the volume of a macroscopic object completely, and to this extent the object is a continuum. It is only as a field-continuum that it coheres.[10]

Wolfgang Köhler, one of the founders of gestalt psychology, recognized that the very concept of discrete particles of matter was nothing more than an artifact of a naive interpretation of vision. As a result, the precepts of both biology and physics were limited by their inability to deal with the ontological reality of functional, self-organizing wholes—the gestalt phenomena of human mental activity.

> In biology the controversy has centered on the problem of whether life processes can be explained physico-chemically or whether vital forces must be postulated. Indeed,

9. H.S. Burr and F.S.C. Northrop, "The Electro-Dynamic Theory of Life," *The Quarterly Review of Biology*, Vol. 10, No. 3 (Sept. 1935), pp. 322-333.

10. Wolfgang Köhler, *The Place of Value in a World of Facts* (New York: Liveright, 1938).

Wolfgang Köhler, a founder of gestalt psychology, advocated an approach to biology that started from cognitive processes.

> the properties of life processes with which biology is concerned are not unlike the psychical phenomena responsible for the Gestalt problem in psychology. This does not mean, however, that the vitalists' doctrine in biology recommends itself as particularly fruitful, for the vitalists' answer precludes the possibility of success in a search for physical Gestalten. The biologists have of course made some attempts at discovering analogies in physics, but thus far little more than vague comparisons with crystal formations have been achieved. . . . The closest approach between general biology and psychology occurs in the theory of nervous functions, particularly in the doctrine of the physical basis of consciousness. Here we have an immediate correspondence between mental and physical processes and the demand seems inescapable that at this point organic functions be thought of as participating in and exhibiting essentially Gestalt characteristics.[11]

Because the thought and language of physics, consequently carried over into biology, had been based on machanistic assumptions, a new conceptual foundation for these sciences would have to be built up from the language governing *cognitive* processes—an approach consistent with Vernadsky's discovery of the subsuming characteristic of the noösphere over both the biotic and abiotic.

According to the machine conceptions, order in nature can only be imposed by certain fixed constraints, a necessary corollary to the idea at the root of the second law of statistical thermodynamics: that natural processes inherently tend toward disorder. It is true that within any given boundary conditions for a given system, there is a definite tendency toward an equilibrium state describable by the second law. However, the principle of direction in that system can also be attributed to strictly physical (what Max Planck called "dynamical"), rather than statistical, principles, such as the system's tendency to reduce its total potential.[12] The machine conception fails even as a beginning point in reasoning. Within certain boundary conditions, which themselves cannot be defined by the second law, even inorganic systems have the capacity for regulation purely through the interaction of the physical forces inherent in the system.

The array of these physical forces active in biological processes is not a subset of, but rather subsumes those found in inorganic systems, and appears to include not only chemical and electrodynamic phenomena, but everything from laser-like biophoton emissions, to nuclear transmutation and superconductivity, processes whose abiotic expression may represent merely "limiting conditions" of their more universal manifestation in life. These processes act to reshape the topological boundary conditions represented by any given physical state of an organism, as in the case of the electric fields governing limb regeneration.

In a machine, the distinction between process and structure is unambiguous; for example, hot gases are conducted through the rigid chamber walls of a car engine. In an organism, the energetic flow required for metabolism literally builds, and constantly maintains, the structure of the organism. Moreover, this energetic flow is part of a continuous process extending from terrestrial, to solar, to cosmic space, begging the question: Are there any strictly inorganic systems for which the second law has universal significance?

Leaving the Womb

The existence of continual, periodically varying, and interpenetrating electromagnetic fields form an invisible part of the terrestrial environment that is as real as the oceans, mountains, and atmosphere, although we may forget about such radiations in the same way a deep sea fish forgets about water. Sources of this radiation include the Earth's magnetic and electric fields, each of which exhibits diurnal and periodic variations in conjunction with the activity of the Sun as well as larger astronomical cycles; natural changes in the atmosphere, such as thunderstorms; cosmic background radiation such as radio and gamma rays; and man-made sources.

In many ways, the evolution of life on Earth has been bound up with the evolution of the electromagnetic fields of the planet, as through the creation of the atmosphere by which the electric fields of the planet are maintained, or the more extreme case of magnetic field reversals, whose cause remains a mystery, but which have historically coincided with mass extinctions. More interesting is a possibility that the magnetic field itself is either a product of, or at least conditioned in some way, by the action of living processes, possibly through the motion of conducting currents in the oceans.[13]

A vast body of experimental work has documented widely varying influences of environmental electromagnetic fields on

11. Wolfgang Köhler, "Physical Gestalten," in Willis D. Ellis, ed., *A Source Book of Gestalt Psychology* (London: Kegan Paul, Trench, Trubner and Co., 1938).

12. Wolfgang Köhler, "On the Problem of Regulation," in Mary Henle, ed., *The Selected Papers of Wolfgang Köhler* (New York: Liveright, 1971)

13. Gregory Ryskin, "Secular Variations of the Earth's Magnetic Field: Induced by the Ocean Flow?," *New Journal of Physics*, June 2009.

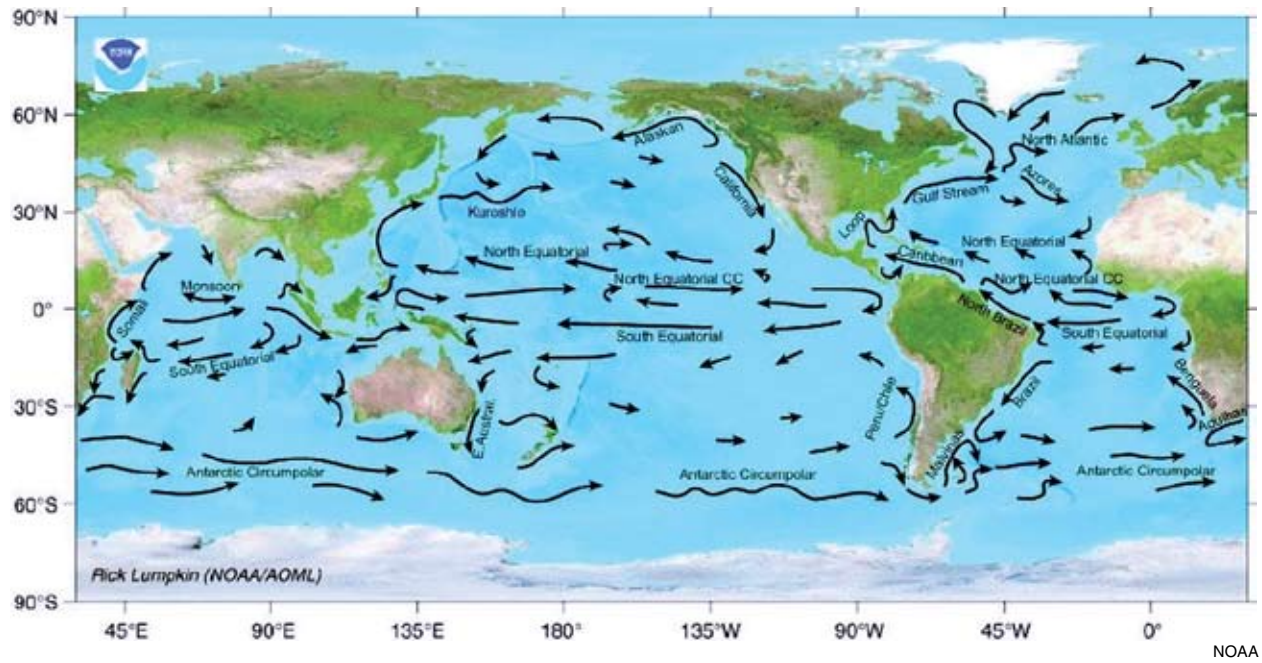


Figure 3
MAJOR OCEAN SURFACE CURRENTS

It is possible that the magnetic field of the Earth is conditioned in some way by the motion of conducting currents in the ocean.

the behavior and internal vital activity of organisms, including all the known plant, animal, and human biorhythms. Such fields act in conjunction with those produced by the organism itself. However, the very broad measurable parameters of electromagnetic radiation, including its frequency spectrum and modulation, intensity, and orientation, and the fact that organisms can be sensitive to extremely slight variations in any one of these, make the correlation of specific effects with specific forms and qualities of radiation difficult to determine. Add to that the corpuscular cosmic rays and their secondary atmospheric by-products, and the potential functional relationships of various radiations and life appear almost infinitely complex.

Ultimately, determining the specific forms of "resonance" between organisms and the energetic phenomena of their environment will depend on learning more about the way organisms exhibit such high degrees of selectivity, one of the clearest expressions of the unique physical space-time of living matter. At the nuclear scale, this includes not only what specific chemical elements an organism will utilize, but also which isotopes. At the molecular scale, this includes not only the elemental and isotopic composition of molecules, but also their *structure,* discovered by Louis Pasteur as the presence of a principle of dissymmetry, reflected in the ability of left- or right-handed molecules to rotate polarized light (electromagnetic radiation).[14]

Bioenergetic phenomena in general should be considered in light of Pasteur and Pierre Curie's work on the principle of dissymmetry, which Vernadsky believed was one of the most important avenues for scientific exploration into the physical space-time manifestation of directionality in living processes.

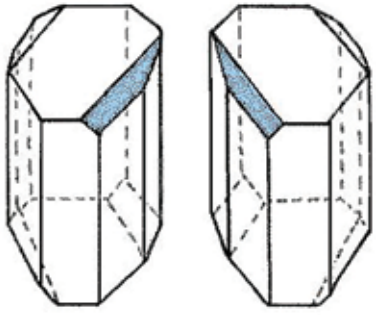
In general, the cyclical character of the relationship of organisms to energetic phenomena must reflect that of organisms to matter: They are utilized and transformed by the organism as part of the continual process of the biogenic migration of matter-energy through the biosphere in its evolution to higher states of development. Defining this selectivity with respect to electromagnetic radiation may help to actually redefine the electromagnetic spectrum itself, with which "living systems may be playing an unimaginably huge concert . . . creating a completely new category of phenomena outside of classical electrodynamics."[15]

Perhaps we won't fully appreciate the subtle, but crucial, nature of our dependence on an appropriate electromagnetic "diet," until we are forced to create it ourselves from scratch—beginning with the first lunar bases, and then en route to and on the surface of Mars.

One example, related to the overall bioelectromagnetic control system first revealed by regeneration, suffices to demonstrate that frontier research in space is no luxury, but rather, an absolute necessity.

14. A recent experiment detected a similar effect for a beam of electrons, with interesting implications for our discussion here. See "Chiral Asymmetry: The Quantum Physics of Handedness," in Mark P. Silverman, ed., *Quantum Superposition: Counterintuitve Consequences Coherence, Entanglement, and Interference* (Berlin: Springer, 2008).

15. Fritz-Albert Popp, "Electromagnetism and Living Systems," in Mae Wan-Ho, Fritz-Albert Popp, Ulrich Warnke, *Bioelectrodynamics and Biocommunication* (Singapore: World Scientific, 1994).



◄ *Louis Pasteur (1822-1895) discovered the principle of dissymmetry in molecules—the ability of left- or right-handed molecules (above) to rotate polarized light.*

Pierre Curie (1859-1906) worked with Pasteur experimenting with dissymmetry.

Bone loss in astronauts in space has long been recognized as a major problem, and it is one that appears closely related to osteoporosis on Earth. However, it cannot be fully accounted for by the mechanical "unloading" of bone stress caused by microgravity, and undoubtedly involves an electromagnetic component. Robert Becker proposed one possible means by which bone might respond to external electromagnetic fields in space.

Bones are able to reshape themselves according to mechanical stress, creating more growth in areas that bear greater compression loads, and compensating by eliminating bone material in other areas. This self-regulating system of growth and loss is governed by electrical signals, and the piezoelectric property of bone may allow it to generate the necessary electrical currents by mechanical stress. Human bone is an intricate structure composed of a matrix that includes tiny apatite minerals of calcium phosphate bound to interwoven collagen fibers, as well as trace elements like copper. Becker found that the trace atoms of copper might act as a kind of electromagnetic "peg" holding the collagen and apatite together, which could be loosened through a disruption of the body's internal electric fields.

Space osteoporosis may result from unnatural currents induced in bone by a spaceraft's rapid motion through the Earth's magnetic field, with a polarity reversal every half orbit, or it may be a direct effect of the field reversal. This abnormality, which may change the activity of bone cells directly, would be superimposed on abnormal responses of bone's natural electrical system, which is almost certainly affected by weightlessness. The unfamiliar external field reversals could also weaken the copper pegs, at the same time that the bones are in a constant state of "rebound" from their earthly weight-induced potentials, producing a signal that says, "No weight, no bones needed." We know that the more even distribution of blood caused by weightlessness registers in the heart as an excess; as a result, fluid and ions, including calcium, are withdrawn from the blood. However, the effect probably isn't caused by weightlessness alone, for the Skylab astronauts did rigorous exercise, which would

NASA

STS-119 Mission Specialist Joseph Acaba, works out in March 2009 on the Space Shuttle Discovery's bike, called an ergometer. Bone loss in astronauts in space is a major problem, and NASA has space exercise regimens to counter the lack of stress on bones in zero-gravity. But research is needed on the possible space electromagnetic effects on bone and other tissue.

have supplied plentiful stresses to their bones. They worked out so hard that their muscles grew, but decalcification still reached 6.8 percent on the twelve-week mission.[16]

Such possible effects, which point to the more general electromagnetic properties of biological regulation, can only be tested by experimenting with artificial electromagnetic fields on astronauts in orbit. In addition, current space biomedical research indicates that bone fracture healing is impeded in reduced gravity conditions. The relationship of ionizing radiation, which is more abundant outside the protection of Earth's magnetic field, to the rate of both fracture healing and bone loss in reduced gravity environments is being studied as well, although primarily in Earth-bound laboratory conditions.

Again, these relationships can only properly be investigated outside of the pervasive electromagnetic and gravitational fields of the Earth. Far beyond the specific effects on bone and other organic tissue, such studies could lead to a new understanding of the broader relationship between ionizing radiation, electromagnetism, and gravitation.

Indeed, radioactive decay itself, a property of the inner structure of atoms once thought immutable, and which is a source of ionizing radiation, has been shown in some cases to correlate with astrophysical cycles.[17] This further underscores that the fundamental properties of even inorganic matter cannot be studied as the isolated phenomena of "particle physics," and calls to mind Vernadsky's emphasis on the role of cosmic processes in shaping the inherent character of all matter. Here lies the true value of a real science-driver program for space exploration, in forcing the combination of fusion and nuclear research, with astrophysics, biology, and physical chemistry, to allow seemingly paradoxical observations to be compared and analyzed across a wide range of experimental domains. This becomes crucial as we confront the prospect of supporting human life outside the "womb" of the Earth.

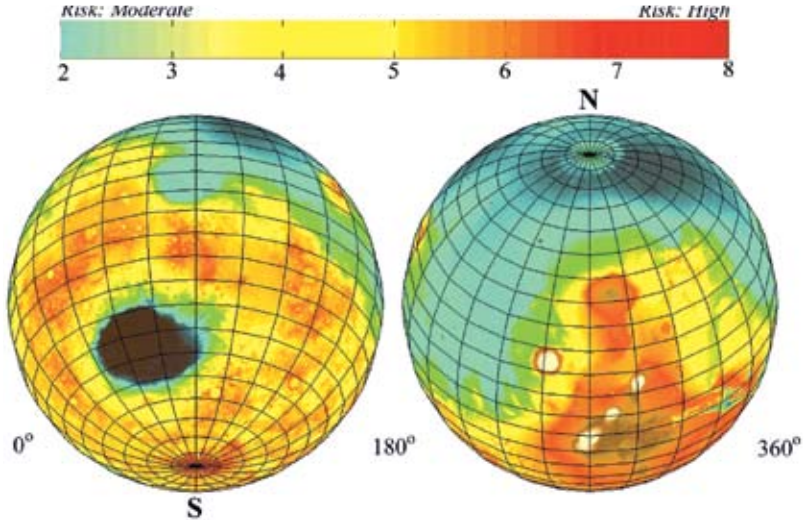


Figure 4
COSMIC RADIATION ESTIMATES FOR MARS

This global map of Mars shows estimates for amounts of high-energy-particle cosmic radiation reaching the surface, which will be a serious health concern for explorers and colonizers of the planet. The estimates are based on cosmic-radiation measurements made on the way to Mars by the Mars radiation environment experiment, an instrument on NASA's 2001 Mars Odyssey spacecraft, plus information about surface elevations on Mars from the laser altimeter instrument on NASA's Mars Global Surveyor.

As on Earth (which has a much thicker atmosphere), the areas with the highest elevation have more radiation, because there is less atmosphere to block out some of the radiation. Colors in the map refer to the estimated average number of times per year each cell nucleus in a human there would be hit by a high-energy cosmic ray particle. The range is generally from two hits (color-coded green), a moderate-risk level, to eight hits (coded red), a high-risk level.

Source: Jet Propulsion Laboratory/JSC/NASA

A New Causality

In a sense, we are faced today with same complex of paradoxes that arose with the simultaneous emergence of atomic science, relativity, and quantum physics in the first decades of the 20th Century. Seemingly continuous processes, such as energetic phenomena, appeared to be organized in the very small as discrete processes. Likewise, discrete phenomena, such as matter, could be represented by continuous processes.

Max Planck and Albert Einstein called for the development of a new concept of causality, rather than the statistical indeterminacy imposed by the quantum mechanists. In this respect, it is worth recalling the words of Planck's student, Köhler, that "Max Planck once told me that he expected our approach [in gestalt psychology] to clarify a difficult issue which had just arisen in quantum physics, if not the concept of the quantum itself."[18]

Vernadsky at the same time recognized that for the truths of science to be universal, the standpoint of the naturalist had to be adopted in order to study the full scope of physical phe-

16. Becker and Seldon, see Note 5.

17. Jere H. Jenkins, Ephraim Fischbach, et al., "Evidence for Correlations Between Nuclear Decay Rates and Earth-Sun distance," Astroparticle Physics, Vol. 32, No. 1, August 2009.

18. Wolfgang Köhler, "Gestalt Psychology Today," Address of the President at the 67th Annual Convention of the American Psychological Association, Cincinnati, Ohio, Sept. 6, 1959. http://psychclassics.asu.edu/Kohler/today.htm#1

Philippe Moussette/NASA

Northern lights in Canada taken with a fish-eye lens. We need to develop a full mastery of the entire electromagnetic spectrum and its role in sustaining human life in the Solar System.

Laurence Hecht

Sky Shields (left) and Oyang Teng, working on the Cosmic Ray Project.

nomena and their expression in all three universal experimental domains of the abiotic, biotic, and noetic.

The basis for this new science of dynamics, as LaRouche has called it, will rest on a mobilization of the scientific and economic means necessary to secure an interplanetary future for mankind, including a full mastery of the entire electromagnetic spectrum and its use to sustain human life throughout the Solar System. This approach will define the meaning of science for the next century, if we have the wisdom to let that knowledge guide our actions in the present.

Oyang Teng is a member of the LaRouche Youth Movement's "Basement" research team. He can be reached at oyangt@gmail.com .

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