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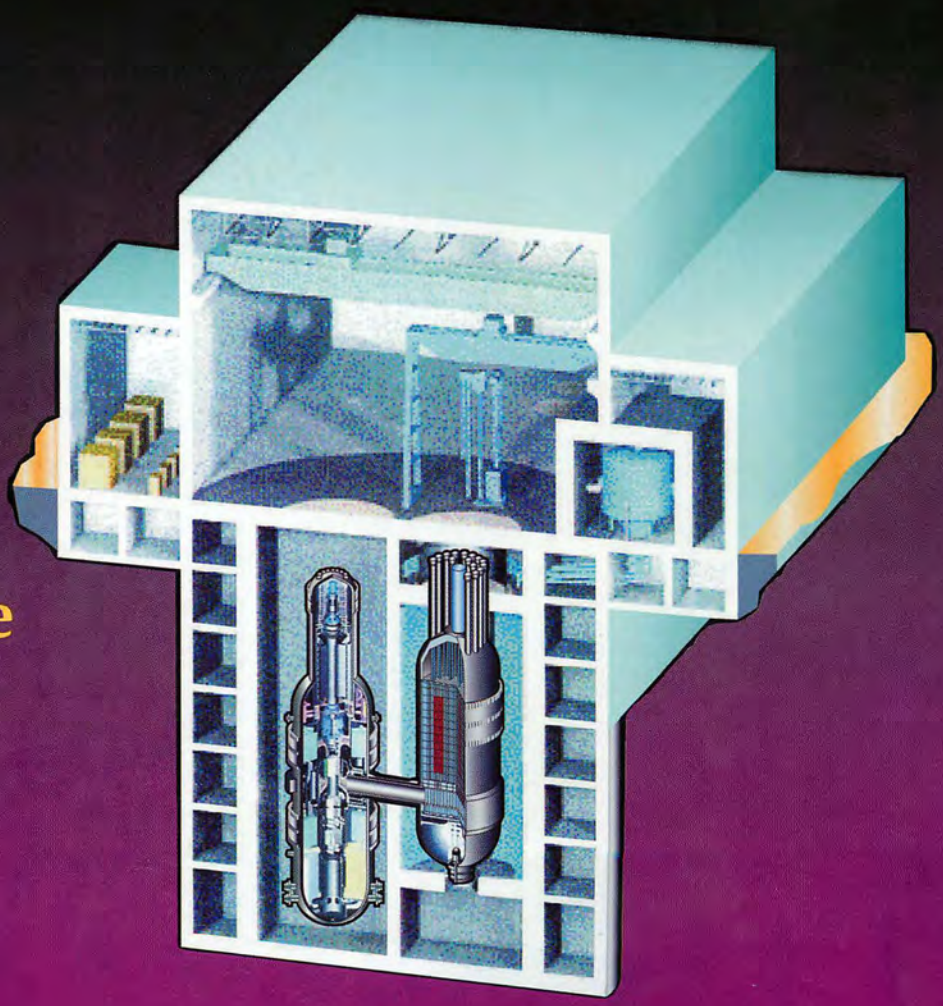

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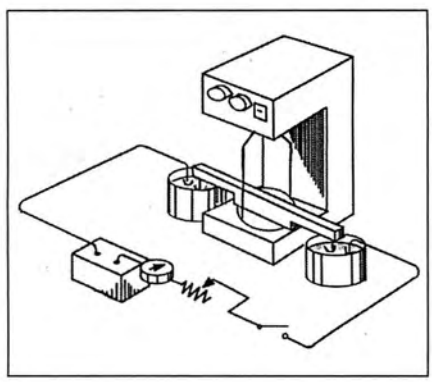

With this device for studying the lift effect of the Ampère longitudinal force, French physicist Rémi Saumont unexpectedly discovered a possible "degravitation." See article, p. 27.

On the cover: Artist's conception of the General Atomics 285-megawatt gas-turbine modular helium reactor (GT-MHR). Illustration courtesy of General Atomics; cover design by Alan Yue.

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SHOULD THE LAW OF GRAVITY BE REPEALED?

The Suppressed Electrodynamics Of Ampère-Gauss-Weber

An iron curtain divides the subjects of gravity and electrodynamics, in today's academically accepted versions of physics. Those attempting to cross it will risk the intellectual equivalent of machine-gun fire. Beyond, lie even more serious obstacles which come, not from outside, but from within the mind of the investigator. To get at the source of those self-imposed shackles, requires that we go beyond the bounds of what is today defined as "physics," into matters usually classified as philosophical, or metaphysical. In doing so, we cannot avoid noticing that there are two schools in physical science, each one so distinct from from the other as to constitute two entirely different domains. It is the unfortunate aspect of our modern legacy that most, even among well-educated scientists, are unaware even of the existence of such a distinction. Yet, if the real history of physics of the 19th century were known, most of what passes as teaching of fundamental topics in that discipline today, would be shown to be, in the best of cases, misdirected, in the worst, willful fraud.

We know of no better way to correct this deficit than to present this review of the conceptual history of 19th Century electrodynamics. We have two purposes. First, to provide the reader with an introduction to the mostly unknown electrodynamic theory of André-Marie Ampère, and his successors—this, as a necessary aid to understanding our feature article on the subject of anti-gravity by the distinguished French research scientist, Dr. Remi Saumont. Second, by exposing a crucial aspect of the suppressed history of gravity, electricity, and magnetism, to address the deeper problem of method holding back science today.

The heart of the matter before us, begins with the hypothesis and experimental validation of the Ampère angular force. Before the discovery by Oersted and Ampère of the effective equivalence of a closed current and a magnet, it appeared that the pairwise forces between bodies were governed by the same law of universal gravitation, which Johannes Kepler had first noted in his 1609 *New Astronomy.*[1] At the time in question, 1819-1821, three known phenomena appeared to behave according to the assumption that the force between two bodies was determined according to the inverse square of their distance of separation. Apart from gravitation, these were the phenomena of *electrostatic,* and *magnetic* attraction and repulsion, investigated especially by Coulomb and Poisson.

In all three cases, there was some question as to the perfect validity of the inverse-square assumption. In the case of magnetism, the impossibility of separating the two opposite poles, made exact measurement of the pairwise relationship of one magnet to another always inexact. This problem of the existence of a "third body" did not entirely go away, even in the case of the most carefully observed of these phenomena, gravitation.

The Ampère Angular Force

In 1826, André-Marie Ampère published a groundbreaking study, summarizing the work of five years of research into the laws of the new science that he had named *electrodynamics.* The results showed, that in the case of the pairwise interaction of two infinitesimally small elements of direct current electricity within conductors, the force between the elements was not simply

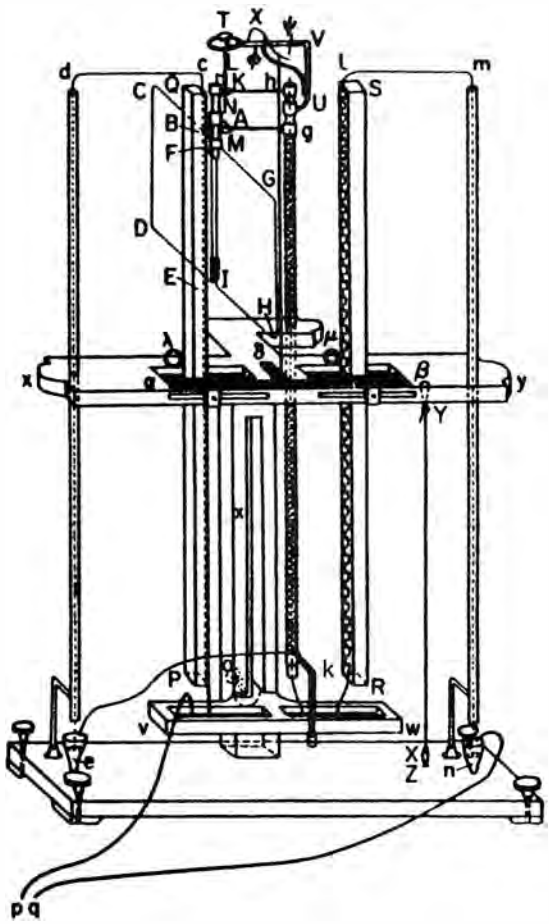
dependent on the inverse square of their distance of separation, but also depended on the angles which these infinitesimal, directional elements made with the line connecting their centers, and with each other. (Included among the effects of the angular force was the result that successive elements of current within the same conductor would tend to repel one another—the longitudinal force.)[2]

Ampère's discovery did not escape the attention of Carl Friedrich Gauss at Göttingen University, the foremost mathematical physicist of the age. Within two years of the publication of Ampère's results, Gauss turned his attention to the matter of firmly establishing their validity. His program, which was not to reach complete fruition until 1846, required, first, the establishment of an *absolute measure* for the force of the horizontal intensity of the Earth's magnetism (a measure of the deviation oft he compass needle from true North). Up to that time, all measure of the strength of the Earth's magnetism was relative, determined by counting the frequency of vibration of a particular magnetic needle. Gauss, a masterful experimentalist as well as the leading mathematician of the age, determined to apply the precision techniques of astronomical measurement to the task. The result was the instrument known as the *magnetometer.* In his paper of 1832, Gauss created a revolution in geophysics, showing how to determine the Earth's magnetic force at any given location and time.[3]

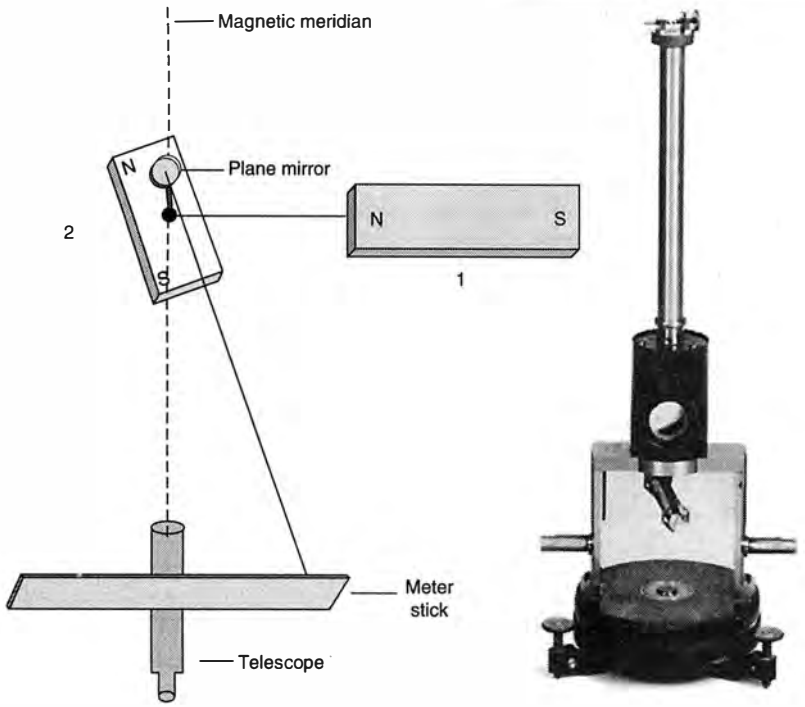
One methodological aspect of the paper on magnetism proved defining for physics to this day. As also for his later work with Wilhelm Weber, in connection with electrical measurement, Gauss determined that the measure of magnetic force must be consistent with the units of measure of *mass, length,* and *time,* already in use in other branches of physics. Owing to the philosophical and historical illiteracy of most contemporary physics teaching, however, Gauss's intention is nearly always misconstrued, to assume that these units are meant to be self-evident scalar quantities. Rather, as a familiarity with Gauss's immediately preceding work on the subject of curvature would show (and, as was made perfectly explicit in the famous 1854 *Habilitation* thesis of his leading student, Bernhard Riemann,[4]) Gauss had already introduced a fully *relativistic* conception into the framework of experimental physics. His 1828 description of the attempt to use state-of-the-art surveying techniques to measure the angular defect of a large terrestrial triangle should make this point evident[5]: As elaborated 26 years later by Riemann, it is the principal task of physics to determine the nature of the non-constant curvature of the non-Euclidean, multiply-connected geometric manifold which defines the action of physical processes.

We will shortly see how, in the joint work with Weber on the determination of the fundamental electrical law, Gauss again introduces an actually relativistic conception, this time in connection with the measure of force.

The reader must be warned, at this point, against a probable misinterpretation of the import of statements made so far: That would be to assume, that, were my perfectly accurate historical statements to be proven valid to his satisfaction, it would only be necessary to correct some names and dates to make the accounts in existing textbooks more or less valid. The reader's persisting error would involve, among other things, a



Ampère constructed many different electrical apparatuses to deduce the relationship of current elements that went into his angular-dependent force law. Here, a reproduction from his 1825 work on the Second Equilibrium Experiment, in which a movable conductor, GH, is suspended between parallel vertical beams, PQ and RS, one containing a straight wire, one a sinuous wire. The experiment shows that GH does not move when current passes through all the wires.



Left, a schematic diagram of the magnetometer designed by Carl Friedrich Gauss in 1831, to measure, for the first time, the absolute intensity of the Earth's magnetic force. Needle 1 tends to produce an angular deflection in the second, oscillating needle, while the Earth's magnetism attempts to realign it with the magnetic meridian. The resulting deflection is measured by reflection of the meter stick into the telescope. By comparing this deflection of needle 2 to the oscillation of the same needle, when acting solely under the influence of the Earth's magnetism, the absolute intensity of the magnetic force is determined. At right is a portable magnetometer built for Wilhelm Weber in 1839.

confusion over our use of the term *relativistic*. From Kepler's rejection of a reductionist treatment of the inverse square law of gravitation discovered by him, through the work of Leibniz, Huygens, and the Bernoullis on the common isochronic principle governing falling bodies and light propagation in an atmosphere, to Gauss's devastating proof of Kepler's planetary harmonics, in his discovery of the orbit of Ceres, there prevailed a conception of the foundation of physics entirely different from that taught in today's respectable institutions of learning. Today, the term *relativistic,* means a formulaic correction to a system of equations and other formalisms premised on an assumed, self-evident notion of three-fold extension in space and one-fold in time. Up to, approximately, the 1881 seizure of power by Hermann von Helmholtz at Berlin University's Physics Department, the leading minds of European continental science rejected such an underlying assumption as sophomoric.

Again, the problem is present-day historical illiteracy. It is essential that the reader grasp that the history we sketch here, is not some "alternative current" in physics. The early 19th Century discoveries, originating in Paris, and spreading into Germany through the influence of Gauss and his students at Göttingen University, were not some alternative current in physics. They remained, throughout most of the 19th century, the central line of thought. Today's academically acceptable physics is built on a radical deviation from that line of thought, imposed, not by reason, but by political maneuverings. (Attempts to provide alternative explanation, rarely represent more than the sort of bureaucratic maneuvering which the advocate supposes to be necessary to maintain job and position.) The proximate source of the errors can be traced to the imposition of the Maxwell electrodynamics and the flawed doctrine of thermodynamics associated with Clausius and Helmholtz. The deeper differences go to the fraudulent representation of the Leibniz calculus by Euler and Maupertuis, and its effect in suppressing the earlier breakthroughs of the French Scientific Academy, as exemplified by the work of Huygens.

The Fundamental Electrical Law of Weber

The experimental validation of the Ampère force was accomplished over the period 1832-1846, by Gauss's assistant and leading experimental collaborator, Wilhelm Weber. Weber's discovery made a revolution in physics, the full implications of which are still unrealized. Worse, today, the underlying discovery itself is almost buried.

Ampère's experimental conclusions drew on a series of brilliant geometrical deductions, derived from the observation of configurations of current-carrying wires in which the forces, presumably, cancelled each other, producing no observable motion. To validate the Ampère Law, one needed to be absolutely sure that the lack of motion was not due to friction in the joints of the apparatus, or related effects. Gauss and his young assistant, Wilhelm Weber, devised a new apparatus, the electrodynamometer, which could directly measure, to within fractions of a second of arc, the angular displacement produced in a multiply wound electric coil by another electrical coil perpendicular to it. By reducing the effects of each of the two coils to that of circular current loops, Ampère's simple law for the force exerted by a current loop could be applied. Placing the coils in different positions, and at different distances from each other, allowed for determinations of the electrodynamic force, geometrically equivalent to those which Ampère had deduced form his null experiments.

The results of a rigorous program of instrument building and experimentation, interrupted by Weber's expulsion from Göttingen University as a result of the political events of 1837, were finally

published at Leipzig in 1846.[6] These results completely confirmed the deductions of Ampère, and also introduced a new physical principle.

The discovery of the phenomena of electrical and magnetic induction had introduced a new element into the considerations of electrical law, not taken up in Ampère's 1826 work. There thus existed, side by side, three seemingly valid descriptions of the electrical interaction: (1) the Coulomb-Poisson law, describing the interaction of two electrical masses at rest; (2) the Ampère law, describing the interaction of elements of moving electricity, and: (3) a description of the laws of induction, elaborated by Emil Lenz and Franz Neumann. In his Fundamental Electrical Law, stated in 1846, Weber achieved the unification of these various phenomena under a single conception.

Instead of the mathematical entities, described as *current elements* by Ampère, Weber hypothesized the existence within the conductor of positive and negative electrical particles. He assumed that the presence of an electrical tension caused these particles to move at equal velocities in opposite directions. If one regards an Ampère current element as containing, at any given instant, a positive and a negative electrical particle, passing each other, then in the pairwise relationship of two current elements, there are four interactions to be considered. By the Coulomb law, these interactions, consisting of two repulsions and two attractions, cancel each other. However, the elementary experiments of Ampère had shown that a motion is produced between the wires, implying the existence of a force not described by the Coulomb law.

For example, two parallel conducting wires attract each other when the current in the two wires flows in the same direction, and repel each other when the opposite is the case. The situation is perfectly well explained under the Ampère force law, when one takes into account the angular relationship of the respective current elements. However, Weber's unifying approach was to assume that the relative velocities of the electrical particles produced a modification in the Coulomb electrostatic force, to produce the resultant force between the wires. Considering all the configurations which Ampère had examined, as well as those arising from the phenomena of induction, he was able to formulate a general statement of the Fundamental Electrical Law. This showed that the general law describing the force of interaction of two electrical particles, depends upon the relative velocities and the relative accelerations of the particles.[7] The Coulomb electrostatic law thus becomes a special case of Weber's general law, when the particles are at relative rest.

It is not too difficult to see that Weber's Fundamental Electrical Law, almost unknown today, is a statement of a relativistic law of physics, long predating the statement of relativity we are accustomed to.[8] Here it is the *force,* rather than the *mass,* which varies with the relative motion. But, not only does it predate the Einstein formulation, it is methodologically far superior. One can, in various ways, attempt to show an equivalence of the two statements, but the usefulness of such efforts is doubtful. The problem lies elsewhere. The two statements lie in two entirely different domains. One is a continuation of the Leibnizian current of physics; the other, whatever the intentions, serves to hide errors embedded in the assumptions underlying the Maxwell equations.

The Weber Constant

In the Weber Electrical Law, there is a relative velocity, corresponding to the constant *c* in his formula, at which the force between a pair of electrical particles becomes zero. The Weber-Kohlrausch experiment, carried out at Göttingen in 1854, was designed to determine this value. It was found to be experimentally equal, in electrodynamic units, to the product of the velocity of light, *in vacuo,* with the square root of 2. That value, became known as the *Weber constant.* In electromagnetic units, it was equal to the light velocity. Bernhard Riemann, who participated in the experiment, soon wrote up the obvious conclusion of a deep connection between light and electrodynamic, or electromagnetic phenomena. What was not obvious, was the answer to a question which Gauss had insisted, in his 1845 correspondence with Weber, be a prerequisite to further progress. That was to find a *constructible representation* of how the propagation of the electrodynamic interaction occurs.[9]

What Maxwell is famously celebrated for, unifying the representation of light and electromagnetic phenomena using a wave conception, was precisely what Gauss—and Ampère before him, had rejected as an oversimplification. Ampère had been so close to the development of the modern wave theory of light, that its founder, his good friend Augustin Fresnel, lived in his Paris apartment at the same time that Ampère was carrying out his electrical researches. To suppose that Ampère, and later Gauss, did not consider a wave representation for electromagnetic propagation is absurd. In order to establish his theory, Maxwell had to disregard the most crucial questions and anomalies that had arisen in the decades-long study of these phenomena by the greatest minds before him. Foremost among these were the angular (or relative velocity) dependency of the electrodynamic force, and the little problem of where gravitation should fit in.

Gravitation

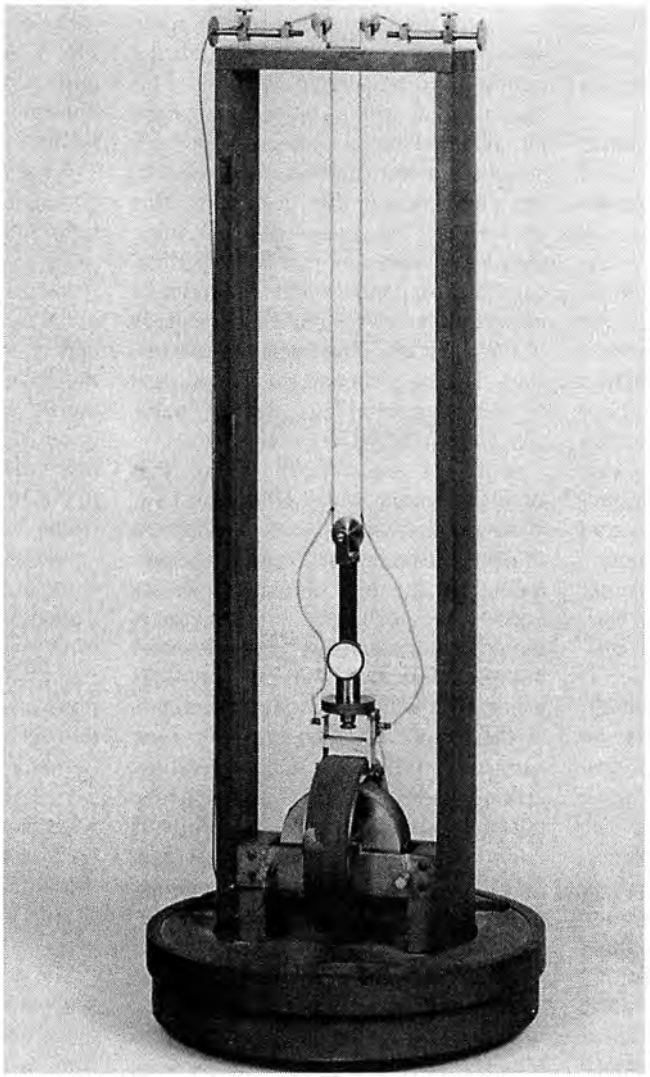
The possibility of subsuming the phenomenon of gravitation under electrodynamics, came up for serious discussion early in this history. One of the more widely discussed contributions was a memoir of about 1830 by O.F. Mossotti, a French physics teacher at the University of Buenos Aires.[10] Mossotti proposed to account for gravitation in the following way: If matter is assumed to be constituted of equal amounts of positive and negative electricity, then, by the usual interpretation, there would be a cancellation of the attractive and repulsive forces. However, if it be assumed that the attractive forces between particles of opposite electrical charge, slightly exceed the repulsive forces of the like particles, a universal tendency for attraction would result.

Weber gave serious consideration to the Mossotti hypothesis. In a posthumously published manuscript on the relationship of electricity and gravitation, he discussed the extreme difficulty of experimentally determining

whether such a small difference between attractive and repulsive forces exists.[11]

In the same memoir, Weber reviews the work of several astronomers, who attempted to apply his Fundamental Electrical Law to correct the law of gravitation, by including terms for the relative velocities and relative accelerations of a pair of bodies. One of the glaring anomalies in the Newton-Laplace theory of gravitation was its inability to accurately predict the advance of the perihelion of the planets, of which Mercury's is the largest. (The phenomenon is famous as being one of the foundational proofs for general relativity.)

In 1864, the Göttingen astronomer C. Seegers proposed to examine the advance of the perihelion from the standpoint that the gravitational force be represented in the same way as the Fundamental Electrical Law.[12] Thus, the relative velocities and accelerations of the bodies of the solar system would have to be taken into account, and the factor $1/c^2$ introduced as a correction. Eight years later, Prof. Scheibner in Leipzig determined a secular variation of 6.73 arc-seconds for the perihelion of Mercury, attributable to the application of the Weber law. In 1872, Tisserand found the value 6.28 seconds for Mercury, and 1.32 seconds for Venus, by applying the Weber law.[13]



Historical Collection of Göttingen University I. Physical Institute

The electrodynamometer, constructed in 1841, which Wilhelm Weber used in the final determination of the validity of Ampere's electrodynamics. It consists of two perpendicular electrical coils. The outer coil is suspended in such a way that its rotation, under the influence of the inner coil, can be precisely determined by observing the deflection of the mirror image of a meter stick in a telescope, as in the Gauss-designed magnetometer. The inner coil can be removed, and placed at various distances.

Another approach to the unification of gravitation with the Ampère-Gauss-Weber electrodynamics, was taken at the beginning of the 20th Century by the Swiss mathematical physicist, Walther Ritz. After brilliant successes in spectroscopy at Göttingen, Ritz launched an attack on the electrodynamics of Maxwell and Lorentz, and attempted to revive the abandoned approach of Gauss, Weber, and Riemann. In a short paper on gravitation, he suggested that the net effect of the electrodynamic forces between two electrically neutral bodies would be an attraction. His approach was not that of Mossotti; rather, he seems to be considering the internal motions of the electrical particles in the atoms as generating such a net effect. The paper is all too short; Ritz died in 1909 at the age of 31. (Deviations in the gravitational force, detected at eclipses, and other anomalous effects suggesting the need for radical revamping of accepted theory continue to make themselves known. The recent work of Maurice Allais, Benedetto Soldano, and Shu-wen Zhou is notable.[14])

Ritz was not alone in his dissatisfaction with the oversimplification of the Maxwell electrodynamics. From the first 1820 breakthrough hypothesizing the origin of magnetism in microscopic electrical currents, the Ampère electrodynamics was seen as a means of gaining insight into the microphysical domain. The enormously complex task of adducing the atomic structure from such indirect evidence as that provided by spectroscopy, came to an abrupt, abnormal halt about the time of the 1927 Solvay conference, where Bohr's great oversimplification of atomic structure was imposed by political thuggery of the worst sort. Here again, we come to the importance of a virtually unknown aspect of Weber's work.

Limiting Velocity and Critical Length

As for electrodynamics, so for the history of atomic theory, the modern teaching is largely a fairy tale. A brief look at two crucial matters will establish this point beyond contradiction, and may help orient the reader to finding a way out of the present impasse. If it appears, at first, that we have "dug him in deeper,"by making matters more complicated than they might have already seemed, we are confident the feeling will be only temporary.

The point here is best summarized by reference to the last two of the memoirs, published in Weber's lifetime, under the title *Elektrodynamische Maassbestimmungen* (Determinations of Electrodynamic Measure). The 1870 memoir, available in English, was the first *to* come to this writer's attention, about a decade ago.[15] The immediate topic is

Helmholtz's objection, that Weber's Electrical Law could lead to the possibility of infinite work arising from a finite amount of work. Weber shows that for Helmholtz's fears to be realized, electrical particles would have to move at enormous relative velocities, exceeding the constant *c*. He thus arrives at a concept of a limiting velocity, quite similar to that found 35 years later in the Special Theory of Relativity, yet arrived at by an entirely different process than that which leads Einstein to this assumption. (Again, the usual warnings apply: Any attempt to find an equivalence or interpolation, as by algebraic means, between the Ampère-Gauss-Weber electrodynamics, and today's Brand *X*, is fruitless. To achieve any useful understanding, the reader must relive the original discovery as if it were his own).

More startling than the immediate answer to Helmholtz's objection, are the conclusions Weber is led to in his preliminary summary of the Fundamental Electrical Law. Here, he introduces for the first time the consideration that the electrical particles possess not merely a quantity of electricity (the magnitude we today call *charge*), but also *mass*. When the consideration of mass is introduced into his velocity-dependent electrical force equation, it results that there is a *critical length* below which the force of repulsion between two electrical particles is changed to attraction, and vice versa! The Weber critical length has the value:

$$\frac{2}{c\,c} \cdot \frac{\varepsilon\,\varepsilon'}{\varepsilon+\varepsilon'}\, e\,e' ,$$

where *e* and *e'* are the electrical quantity (charge) of the two particles, ε and ε' the masses, and *c* the Weber constant.

It is among the delightful ironies of the official cover-up known as modern scientific historiography, that the expression for the classical electron radius (a concept which is not supposed to come into existence for another 30 or more years), falls out of Weber's expression—indeed, as a trivial case!

It gets more interesting. Weber has already dared, in the 1870 paper, to conceive the notion we know today as the proton-electron mass ratio, which leads him to wonder as to the possible motions of the different configurations of particle pairs. It turns out that, according to his relativistic electrical law (one which was never considered in the accepted, modern formulations of atomic theory), it is possible to develop an orbital system for the case of a lighter electrical particle of one sign, orbiting a heavier particle of the opposite sign! It is also possible for two similar particles of the same sign to develop a closed system of oscillations along the straight line connecting them.

We leave to a future time, the treatment of the last major accomplishment of Weber, the refutation of Clausius' thermodynamics and the Helmholtz Energy Principle.[16] The problem with the fraud known as modern, academically accepted science, is not merely that credit has not been given for these prior discoveries. Far more devastating is that, in the modern formulation of notions similar to those that Weber had derived far earlier, there is no lawful derivation. We fly, rather, by the seat of our pants, hoping to reach the destination intact.

—Laurence Hecht

Notes

1. Johannes Kepler, *New Astronomy,* William Donahue, transl. (Cambridge: The University Press, 1992) p. 395
2. André-Marie Ampère, "Memoire sur la théorie mathématique des phénomenes électrodynamiques uniquement déduite de l'experience," in A.M. Ampère, *Electrodynamiques, uniquement déduite de l'experience,"* (Paris: A. Hermann, 1883). A partial English translation appears in R.A.R. Tricker, *Early Electrodynamics: The First Law of Circulation* (New York: Pergamon, 1965) pp. 155-200.

   A review of the Ampère-Gauss-Weber electrodynamics appears in Laurence Hecht, "The Atomic Science Textbooks Don't Teach," *21st Century,* Fall 1996, pp. 21-43.

   The law of force which Ampère derives is:

   $$F = \frac{i\,i'\,ds\,ds'}{r^2}\,(\sin\Theta\sin\Theta'\cos\omega - \tfrac{1}{2}\cos\Theta\cos\Theta')$$

   where ds, ds' are the current elements of intensities *i, i'*, *r* the distance connecting their centers, Θ and Θ' the angles which *r* makes with them, and ω the angle they make with each other.
3. Carl Friedrich Gauss, *Die Intensität der Erdmagnetischen Kraft auf absolutes Maass zurükgeführt,* ed E. Dorn, *Ostwald's Klassiker der Exakten Wissenchaften,* Vol. 53 (Leipzig: Wilhelm Engelmann, 1894). English translation in *21st Century Science* archive (The Intensity of the Earth's Magnetic Force, Reduced to Absolute Measure).
4. Bernhard Riemann, "On the Hypotheses Which Lie at the Foundations of Geometry," in David Eugene Smith, ed., *A Source Book in Mathematics* (New York: Dover Publications, 1959) pp. 411-425.
5. Karl Friedrich Gauss, *General Investigations of Curved Surfaces,* transl. Adam Hiltebeitel and James Morehead (Hewlett, N.Y.: Raven Press)
6. Wilhelm Weber, "Elektrodynamische Maasbestimmungen: über ein allgemeines Grundgesetz der elektrischen Wirkung," *Werke* (Berlin: Julius Springer, 1893) Bd. 3, pp. 25-214. English translation in *21st Century Science* archive (Determinations of Electrodynamic Measure: Concerning a Fundamental General Law of Electrical Action).
7. $F = \frac{ee'}{r^2}\left(1 - \frac{1}{c^2}\cdot\frac{dr^2}{dt^2} + \frac{2r}{c}\frac{d^2r}{dt^2}\right)$
8. More than a decade before the publication of Weber's 1846 paper, one can find an 1835 entry in Gauss's Notebooks, showing a hypothesized form of the electrodynamic force law, dependent on relative velocity and acceleration, that is essentially equivalent to that which Weber used in the 1846 publication. Interestingly, the Gauss formulation appears on the same page as an alternative formulation, which was the one James Clerk Maxwell chose to use in his text *Treatise on Electricity and Magnetism* to falsely imply a difference in electrodynamic views among the three collaborators, Gauss, Weber, and Riemann.
9. "Text of the Gauss-Weber 1845 Correspondence," (in "The Atomic Science Textbooks Don't Teach,") *21st Century,* Fall 1996, pp. 41-43.
10. O.F. Mossotti, "On the Forces which Regulate the Internal Constitution of Bodies," in R. Taylor, ed. *Scientific Memoirs,* Vol. 1, pp. 448-469.
11. Wilhelm Weber, "Elektrodynamische Maassbestimmungen, insbesondere über den Zusammenhang des elektrischen Grundgesetzes mit dem Gravitationsgesetze," *Werke* (Berlin: Springer, 1894), Bd. 4, pp. 479-525. English translation in *21st Century* archive, (Determinations of Electrodynamic Measure: Particularly in Respect to the Connection of the Fundamental Laws of Electricity with the Law of Gravitation).
12. C. Seegers, "De motu perturbationibusque planetarum secundum legem electrodynamicum Weberianam solem ambientium," Göttingen, 1864
13. Tisserand, "Sur le mouvement des planètes autour du Soleil d'apres la loi electrodynamique de Weber, *Compt. rend.* Sept. 30, 1872.
14. Maurice Allais, "Should the Laws of Gravitation Be Reconsidered," *21st Century,* Fall 1998, pp. 21-33.

    Benedetto Soldano, "Space Probe Acceleration Anomalies Suggest Nonequivalence," *21st Century,* Summer 1999, pp. 66-69, 75.

    Shu-wen Zhou, "Abnormal Physical Phenomena Observed When the Sun, Moon, and Earth Are Aligned," *21st Century,* Fall 1999, pp. 55-61.
15. Wilhelm Weber, "Elektrodynamische Maasbestimmungen, insbesondere über das Princip der Erhaltung der Energie," (1871), *Werke* (Berlin: Springer, 1894), Bd. 4, pp. 247-299. English translation in *Philosophical Magazine,* 4th series, Vol. 43, No. 283, January 1872, pp. 1-20, 119-149 ("Electrodynamic Measurements—Sixth Memoir, relating specifically to the Principle of the Conservation of Energy").
16. Wilhelm Weber, "Electrodynamische Maasbestimmungen, insbesondere über die Energie der Wechselwirkung," *Werke,* Bd. 4, pp. 362-412.

Letters

A Dissatisfied Reader

To the Editor:

I have to say that your magazine blows. It's called *Science & Technology,* but it might as well have been written by Republican business economists. You have been compared to the Flat Earth Society, because of your stance on global warming. How can you deny that it exists? How could protecting forests, and doing prescribed burns kill the forest? It's obvious the forests are dying because timber and paper companies are physically removing the trees from the forest. Who pays for the magazine, corporations? Animal testing is *not* justified, nor objectively preferred.

Aside from environmental issues, how cliché is it to reserve six pages dedicated to blaming some form of the media for the increased violence amongst children? that's not even scientific! That's an opinion! Why don't you report about neurotic, distant families, if you want to write about social topics like children's behavior. There was nothing technological or scientific about your magazine. This would [be] *au courant* in the Dark Ages! At least, report on the provocative, new forms of energy, like wind, biomass, and solar. Dams aren't acceptable any more: to rivers, salmon, wildlife, and humans. Get with it already.

Allison Mannos
Burbank, Calif.

The Editor Replies

You've pushed every button of the modern environmentalist belief structure. But, do you know *why* you believe these things?

To answer a few of your questions:

- "Republican business economists?" We don't have any, that I know of, around here. Our leading contributor on economics topics, Lyndon LaRouche, was put in prison by a conspiracy involving George Bush, Sr. and Henry Kissinger.
- "Global warming?" Last winter was the coldest on record in the United States. Sound climate science predicts a coming new Ice Age.
- "Blaming some form of the media for the increased violence amongst children?" They may not do it all, but they sure help—and a lot of them really are "Republican business economists."
- "Provocative new forms of energy like wind, biomass, and solar." Have you compared the energy flux density of these technologies to nuclear, or fusion? Using them in place of modern technological forms of energy production is a prescription for genocide. And they're not "new"—last we checked, they've been around since Adam.

Science is not knowing something, it is knowing how you know it. A more careful reading of any issue of our magazine, will, we hope, help you and others to learn how to do this. For us, that is the most important task for the 21st Century.

Materialism and Mind

To the Editor:

Laurence Hecht's intelligent response to the biology professor ("Editorial: "Is the Mind a 'Thing'?" Fall 2000, p. 2) hits the nail on the head. It's clear that the materialist view never created, nor will create, a thinking machine of any type, for one simple reason: it suffers from a fundamental error of reasoning.

To give one example: What is the only thinking machine (rudimentary and imperfect), sitting on top of our shoulders, made up of 80 percent water, and the other 20 percent carbon, nitrogen, phosphorus, sulfur, and inorganic salts, whose cost (in the present free market) does not exceed two dollars?

Fortunately, when these elements are mixed in a test tube, not a single spark of life appears—something is missing. Maybe mixing all the components of a neuron in proper proportion?—again failure. The biologist begins to open his mind; biological reactions are ordered and sequenced both within and without various complex internal structures, such as mitochondria, ribosomes, and others. But who determines this discontinuous sequence? Is it the DNA, the RNA? The stubborn materialist biologist does not give up. It is a hard nut to crack. He struggles vainly, ever more mired in the intellectual quicksand, but getting nowhere.

With a great ability to distinguish the forest from the trees, his whole well-ordered approach to life leads him to read the works of the 17th Century German philosopher and sage, G.W. Leibniz. It then becomes clear to him that, with his philosophy, he was not going to succeed in building thinking machines. He sees, rather, that the combination of present reductionist ideas with the monistic school of thought, would lead to a level of thought far above the present. The professor rushed to the nearest bookstore. . . .

Finally, in a previous issue of *21st Century,* it says that Russian scientists have detected that living cells can synthesize needed elements which they lack. Could this be cold fusion going on inside the cellular machinery? Very strange! Will the tokamak or Sandia device [Z-pinch] become obsolete and outdated?

Alexander Tkachinski
Buenos Aires, Argentina

The Editor Replies

Thank you. Yet, by agreeing with me, you have provoked more doubts and paradoxes in my mind. How difficult this question is to define: What is life? (And even more so: What is thought?) Might there, for example, come a time at which life might be created from non-living substance by human intervention?

Pasteur insisted, rightly I think, that life only comes from life. Yet, we are life. And the non-living is, nonetheless, "created" substance. Does not the principle of life exist, from the beginning, in all substance?

Chernobyl and Thyroid Cancer

To the Editor:

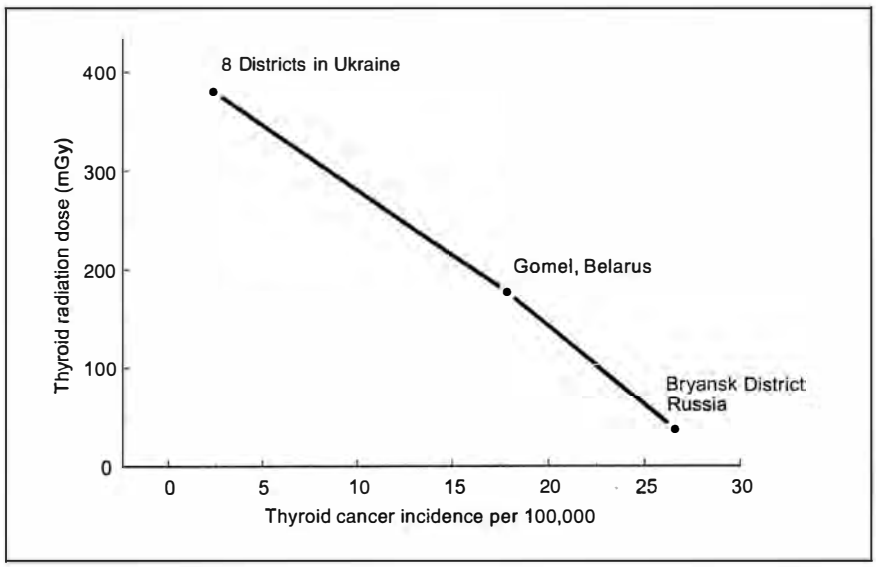
Prof. Jaworowski's articles in *21st Century* and his *Physics Today* article (May 1999, with his rejoinders (April and May 2000) have served the very useful and necessary purpose of placing health aspects of radiation in their proper perspective. Nevertheless, I am somewhat ambivalent about the following points made in his most recent *21st Century* article, "The Truth About

Chernobyl Is Told" (Winter 2000-2001, pp. 17-19).

Point No. 1: Jaworowski's Figure 1 comparison of children's thyroid cancer incidence rates vs. radiation dose shows Gomel, Belarus, to have a lower cancer incidence rate that that of the relatively nearby, but less contaminated, Bryansk District, Russia. But counter-evidence for a causative relationship between radionuclide deposition and cancer appears to lie in the claim that the majority of Gomel region cancers correlate with I-131 rainfall deposition patterns (R.F. Mould, *Chernobyl Record,* Institute of Physics Publishing, Philadelphia, 2000, p. 269). Nevertheless, Jaworowski's statement remains entirely factual, the bases of which can either be deduced from or are stated by Mould (loc. cit., p. 272, Tables 8.10 and 8.12).

Point No. 2: Jaworowski states that many of the reported thyroid cancers could have arisen from intense health screening after the accident, uncovering "occult" thyroid cancer, i.e., those which do not cause visible clinical disturbances during a person's lifetime. However, Mould (loc. cit., p. 277) denigrates this explanation by stating that formal screening did not make a significant contribution to diagnosis, with over half the thyroid cancer in children being found during routine school examination, including palpation of the neck. Mould (loc. cit. p. 268) also states that the unexpected aggressiveness of the detected thyroid tumors leads to the conclusion that the increased incidence does not entirely result from the screening, because if it did, the increased incidence would be of the more usual non-aggressive type.

I do not claim any particular Chernobyl expertise, and rely quite heavily on Mould, who, for all I know, may be an establishment mouthpiece parroting the scientific establishment's current "party line." Also, I am rather suspicious of any claim that tumors were uncovered over the routine course of events, since it strains credulity that in highly contaminated areas, e.g. the Gomel rayon of the Gomel oblast, there would not be an overwhelming temptation to have the populace examined with a "fine tooth comb." This likelihood, coupled with the areas populace's seemingly insatiable appetite for medical and other benefits should be taken into account in any analysis of the Chernobyl event.



Any of Prof. Jaworowski's comments or counter-comments would be welcome.

Daniel P. Hayes, Ph.D.,
CHP Scientist,
Radioactive Materials Division
Office of Radiological Health
New York, New York

Editor's note: The views expressed are those of the author and do not necessarily reflect the official policy or views of the New York City Department of Health.

Prof. Jaworowski Replies

The data on which Figure 1 in my paper is based are from Table 40 in the United Nations Scientific Committee on the Effects of Atomic Radiation report, *UNSCEAR 2000:* "Estimates of collective thyroid doses to populations of Belarus, the Russian Federation, and Ukraine." and from the Report's Table 57: "Thyroid cancer incidence rates in children under 15 years old at diagnosis."

From Table 40, I calculated the per capita thyroid radiation doses. The extensive UNSCEAR data are probably more dependable than those in Mould's 2000 book, *Chernobyl Record,* which do not present thyroid doses for all the contaminated regions of the three countries, but only iodine-131 rainfall deposition in Gomel region, and a crude cesium-137 deposition (two values: >185 kBq/m^2 and <185 kBq/m^2) for only 58 Russian children. It is difficult to understand Mould's arguments, because for a discussion of causal relationship between Chernobyl radiation and registered thyroid cancers, he is not using the thyroid doses.

UNSCEAR's thyroid dose estimates are based on about 350,000 direct measurements of iodine-131 in the thyroids. In addition, in locations where such measurements were not done, the thyroid doses were reconstructed by means of relationships using available data on iodine-131 and cesium-137 deposition, exposure rates, cesium-137 whole-body burdens, or concentrations of iodine-131 in milk.

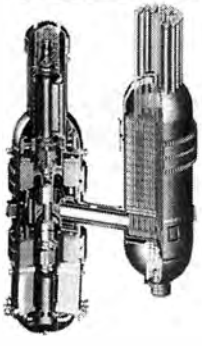
Mould cited in his book the UNSCEAR 2000 report, so it is not clear why he used so few limited data on iodine-131 and cesium-137 deposition, and not the UNSCEAR data on thyroid doses which cover most of the contaminated regions.

Before a screening program for thyroid cancers and nodules was started in Chicago, Illinois, by the Michael Reese Hospital in 1974, the incidence of thyroid cancers and nodules was 19.7 per 100,000. During the screening period, 1975-1979, this incidence rate increased to 418.9 per 100,000—that is, by a factor of about 21. (See reference in Jaworowski, *21st Century Science & Technology,* Spring 1998). This increase was the result of detecting the "occult" thyroid cancers.

Exactly the same occurred in Belarus, Russia, and Ukraine, where, prior to 1986, there were no data on thyroid cancers in children. According to

Continued on page 87

Stuart Lewis



General Atomics

Sen. Pete Domenici's bill sets a goal of 2004 for building a demonstration fourth-generation nuclear reactor. Here, the GT-MHR.

DOMENICI BILL (S.472) GIVES TIMETABLE TO DEVELOP NEW NUCLEAR REACTOR

Sen. Pete Domenici (R-N.M.) introduced a bill, March 7, to authorize federal funds for study of the new, supersafe, fourth generation nuclear reactors. With 11 co-sponsors, the Nuclear Energy Electricity Supply Assurance Act of 2001 would authorize $50 million in fiscal year 2002, to select and design at least one Generation IV system for demonstration by Sept. 30, 2004.

The bill also states that no federal funds shall be used to support international organizations engaged in financing or developing electricity that fail to include nuclear energy. These institutions include the International Monetary Fund, the World Bank, the Agency for International Development, and the Overseas Private Investment Corporation. The bill also calls for reform of the Nuclear Regulatory Commission to facilitate the development of new nuclear technology; directs the Department of Energy to study and report on the possibility of completing unfinished nuclear plants; and authorizes funding to upgrade nuclear and other science education.

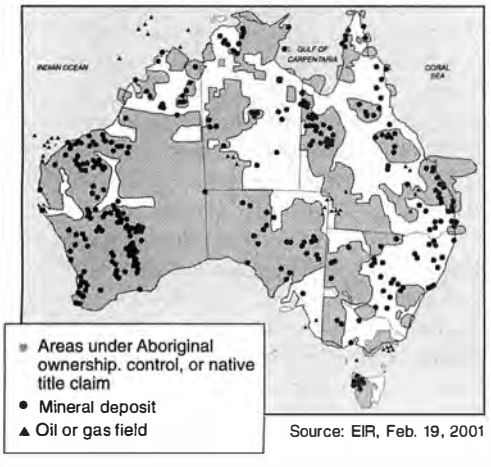
FIRST HIGH-TEMPERATURE SUPERCONDUCTOR CABLE READY IN DETROIT

Three new cables made of a high-temperature superconducting material will soon replace nine oil-cooled, copper cables now carrying 100 megawatts of electricity to Detroit customers. The $5.5 million project is the first such large-scale application for the new material. High-temperature superconductors were discovered in 1986 at IBM's Zurich Research Laboratory. Ordinary metallic superconductors can be brought to a resistance-free, or superconducting state, only by cooling them to a few degrees above absolute zero. High-temperature superconductors become resistance-free at temperatures at or above 77° Kelvin, the boiling point of liquid nitrogen. The relative cheapness of liquid nitrogen held the promise of new applications for the materials, but first it was necessary to find a way to make wire out of the brittle ceramics.

The cable in the Detroit project is a BSCCO ("bisco") superconductor, containing bismuth, strontium, calcium, copper, and oxygen. The American Superconductor Company of Westborough, Mass., which pioneered the process, packs the granular BSSCO material into silver tubes, extrudes them into microfilaments, and bundles the filaments into wires. These are sent to a Pirelli plant in Milan, Italy, where the wires are helically wound around a channel carrying liquid nitrogen. Just 900 pounds of the superconducting wire, will replace 25,000 pounds of copper wire. Operation of the cable at Detroit Edison's Frisbie Substation is scheduled to begin this summer.

WHY BRITAIN'S QUEEN ELIZABETH JUST LOVES HER ABORIGINALS

A glance at the map of Australia showing the overlap of the areas under Aboriginal ownership, control, or native title claim, with the locations of large mineral deposits or oil or gas fields, makes very clear why various groups in the service of the Queen, have upped their attack on the LaRouche affiliate in Australia, the Citizens Electoral Council (CEC). The Australia Anti-Defamation Commission, Inc. (ADC), whose board includes four members of the British Privy Council, has branded the CEC as "racist" for calling Aboriginal land rights in Australia "a fraud concocted by Prince Philip" and his Worldwide Fund for Nature. In fact, as in Brazil (see page 69), the environmental movement has used the banner of "indigenous people's rights" to sequester large land areas and their mineral resources away from the use of the state and into the hands of private, multinational interests.



Source: EIR, Feb. 19, 2001

As documented by the CEC, Queen Elizabeth is the largest shareholder and dominant political power in Rio Tinto, the largest mining company in the world. Rio Tinto is the dominant corporate presence in Australia, and has been the single largest funder of Aboriginal land rights for decades. The Queen has been personally involved in the land rights project, inviting indigenous leaders to Buckingham Palace, and visiting "sovereign" Aboriginal land.

FREEMAN SPEAKS AT NASA AMES ON 'THE EXTRATERRESTRIAL IMPERATIVE'

21st Century Associate Editor Marsha Freeman gave an invited presentation at the NASA Ames Research Center in California March 2, on "The Extraterrestrial Imperative: Why Man Must Explore." She began by introducing physical economist Lyndon LaRouche's concept of how man's unique capability for cognition, realized through the Renaissance, was the driver for the increase in population, population density, and life expectancy that has characterized the past 500 years. But we are now at the cusp of this curve, which is already headed downward in Africa, Russia, and other nations.

Freeman amplified the idea of the uniqueness of man, citing Vladimir Vernadsky's concept of the *noosphere*--his understanding of the impact of human creative thought upon the biogeochemical development of the Earth. That space is the mission driver to move the world back on to the exponential growth curve begun in the Renaissance, was demonstrated using space scientist Krafft Ehricke's concept of the extraterrestrial imperative. Ehricke had developed this idea in the early 1970s, to counter the limits-to-growth ideology then being used to justify no-growth policies, Freeman explained.

Marsha Freeman, addressing the "Contact 2001" conference at NASA Ames in early March.

ANIMAL RIGHTS LEADER BOASTS OF DISDAIN FOR LIFE—ANIMAL AND HUMAN

Ingrid Newkirk, president of People for the Ethical Treatment of Animals (PETA), brazenly told a Reuters reporter that she hoped foot-and-mouth disease would come to the United States. "If that hideousness came here, it wouldn't be any more hideous for the animals—they are bound for a ghastly death anyway. But it would wake up consumers." Newkirk is a founder of the terrorist-condoning animal rights group, which has an annual income of $17 million.

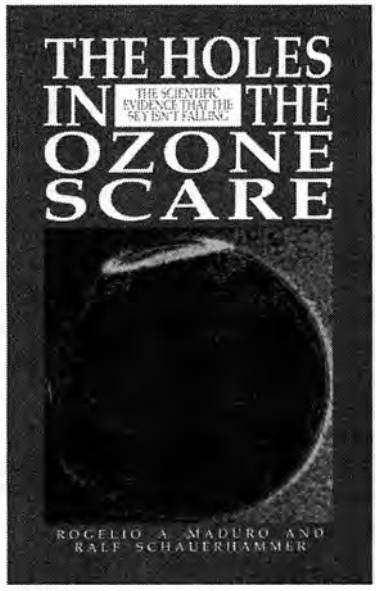
MEL GOTTLIEB, DIRECTOR OF PRINCETON FUSION LAB, DIES

Dr. Melvin B. Gottlieb, who headed the Princeton Plasma Physics Laboratory from 1961 to 1980, died Dec. 1, 2000, at age 83. Gottlieb led the fusion lab during an exciting period of successful fusion experiments and tokamak building, before budget cuts shut down Princeton's Tokamak Fusion Test Reactor and other research programs in the 1990s. He also pioneered international collaboration in fusion, and was one of the first Westerners to visit the Soviet Union's fusion program. In February 1981, the Fusion Energy Foundation, publisher of *21st Century*'s predecessor magazine, paid tribute to Gottlieb with a banquet attended by 350 supporters, and addressed by three generations of fusion scientists who worked with him.

***21ST CENTURY* BOOK CREDITED AS LEADING OPPOSITION TO OZONE SCARE**

In a book just released by Cambridge University Press, *The Ozone Layer: A Philosophy of Science Perspective,* author Maureen Christie, spends 17 pages discussing *The Holes in the Ozone Scare,* by Rogelio Maduro and Ralf Schauerhammer. Christie describes *The Holes in the Ozone Scare,* published by 21st Century Science Associates in 1992, as the "leading work from the dissenting camp." A lecturer at the University of Melbourne, Christie justifies her focus on the book, by noting another author's evaluation that the Maduro-Schauerhammer book "appears to have been the single most influential document in the 1990s among critics of the CFC-ozone hole hypothesis."

Christie says that one can't dismiss the book just because it has similarities with other pseudo-scientific works. "The arguments that are put forward must be examined in detail and judged on the evidence. . . ." However, these niceties aside, Christie admits, "This task will not be undertaken here." Instead, she takes potshots at Maduro and Schauerhammer, and concludes: "I cannot accept that their book is part of a scientific debate, for the reasons that have emerged in this discussion. A more appropriate view is that the scientific debate is now closed, with a clear consensus behind the orthodox views of the ozone hole, and chlorine-mediated global ozone depletion."

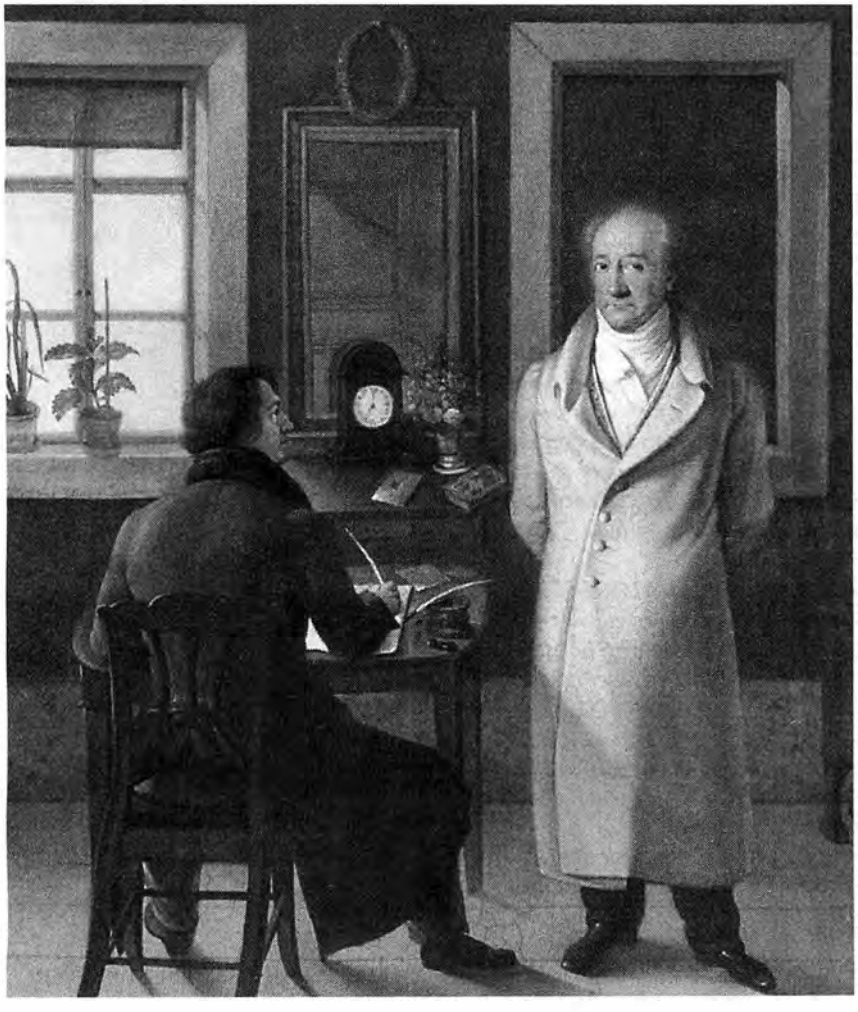


The Holes in the Ozone Scare, *"the single most influential document in the 1990s among critics of the CFC-ozone hole hypothesis," is available from* 21st Century, *at $18 postpaid.*

The Natural Science of Johann Wolfgang v. Goethe

by Ralf Schauerhammer

For Germany's 18th Century poet, science was developed from poetry, and science and art were inseparable. Through his universal approach, Goethe discovered the human intermaxillary bone, conceived of the "original plant," and developed a theory of colors opposed to that of Newton, whose entropic philosophy he vigorously attacked.



Siftung Weimarer Klassik, Goethe—Nationalmuseum

Goethe (standing) dictates to his secretary, John, in an oil painting by Johann Josef Schmeller, 1831.

Introduction

Johann Wolfgang von Goethe saw himself not only as a poet, but as a universal scholar, and, in particular, as a natural scientist. He took it as a diminution of his personality to be designated a poet alone, and said of himself:

> For more than half a century I have been known, in the Fatherland, and abroad as well, as a poet, and at any event have passed for one; but that I have, with great attentiveness, industriously troubled myself with nature in her general physical and organic phenomena, and steadily, quietly, and passionately pursued serious observation—this is not so generally known and still less given attention.

In old age, the isolated Goethe expressed himself even more sharply in a conversation with Eckermann, in which he spoke with bitter defiance:

> I don't pride myself on all that I have accomplished as a poet. Outstanding poets have lived in my time, yet more excellent ones lived before me, and they will come after me [as well]. But that in my century, I am the only one who knows the right way in the difficult science of colors—for that I give myself some credit, and there I have a consciousness of superiority over many.

How far Goethe was right in this estimation,

scholars have debated to this day. One can confirm, with shock and surprise, how each scholar in his time brings forth citations of "his Goethe"; whether empiricist, Romantic, Darwinist, Anthroposoph, Nazi, Frankfurt School follower, or New Age freak—all drag out Goethe's natural science, finally understand it "correctly," and find there exactly what they need. But Goethe, through his Spirit of the Earth in *Faust,* has already answered them all: "You look like the Spirit that possesses you, not like me!"

If it was already difficult to judge the worth of Goethe's natural scientific work during his lifetime, then it is much more difficult today. For since that time, there has become entrenched a development that Goethe recognized and rejected, without being able to suspect the proportions that it would one day reach. Today—and this, for the universalist Goethe, were completely incomprehensible and unacceptable—the science of the mind and the science of nature, art and natural science, heart and head, are completely separated.[1]

For Goethe, the separation of natural science and art was a thoroughly grave mistake. In the publication *Zur Naturwissenschaft* in 1817, he wrote a warning:

> Nowhere was it admitted that science and poetry may be unified. It was forgotten that science has developed from poetry; it was not considered, that with a revolution of the times, both could very well meet again, in friendship and to mutual advantage.

This is exactly what Friedrich Schiller expressed in his poem, "The Artists," with the words:

> Only through the morning-gate of beauty
> Did you enter into wisdom's land.

This does not mean a romantic sameness, a complementarity between left and right halves of the brain or similar trash that is foisted on Goethe unceremoniously. Natural science that deserves the name, in Goethe's view, is science because it raises itself above technical and mechanical studies, and creatively "composes" new knowledge. Such thought is not possible without "poetic passion." Conversely, art, as opposed to cheap entertainment, is only really beautiful if it playfully brings to expression the universal laws of creation. The same faculty in the human mind is responsible for both, and for this reason the one form can arise from the other, and reunite itself with the other on a higher level.

Goethe then goes a step further. Not only is it false to separate nature and art, but man himself may not and cannot withdraw from nature when observing nature. The "objectification" of nature by the empiricists, who set nature over against mankind, as a thing in itself, leads, according to Goethe's conviction, to the error of believing that nature must remain hidden and unknown to man for the most part. Goethe expressed this in a poem that he wrote in an album, explicitly to physicists. Specifically, it was directed against the then well-known Swiss natural scientist Albrecht von Haller, who in his poem, "The Fallacy of Human Virtue," claimed that it were impossible to penetrate the inner secrets of nature. Goethe's lines characterize the lines in italics immediately above them, which were taken by Goethe directly from Haller's poem.

> Indeed!—
> To the Physicist
>
> *"Into Nature's inner holy—"*
> O you Philistine!—
> *"No mind fully penetrates;"*
> How little can you mean
> To me, my brother, my sister;
> Such a word we'll not remember:
> By our place, we consider
> We are there, in the inner.
> *"Happy he! who knows only*
> *Her outer shells and gates."*
> For sixty years I've heard such words repeated,
> Upon them my curse, although unheeded;
> Say I a thousand, thousand times over,
> Her *all* she gives us, richly and well;
> Nature has neither shell
> Nor secret center,
> She is all at once, together;
> First examine and explore,
> Whether you be shell, or core.

The core of nature is in the heart of man. Natural science, Goethe insisted, may never let that truth out of its sight. In the examination of Goethe's natural science we are, ever and again, confronted with this question. Yet, at the outset, let those, who are all so ready to treat Goethe's "unity of nature" as of a piece with today's prevailing green ideology, be told: Take a look at the decisiveness with which Goethe, in his lifetime, declared himself for technological progress in all spheres of activity. He would have laughed today's Greens to scorn!

Discovery of the Human Intermaxillary Bone

Goethe's discovery of the human intermaxillary bone is a prime example of his way of pursuing natural science. In the skulls of animals, the intermaxillary (middle) bone of the upper jaw is generally clearly recognizable. Immediately to the right and left of the nasal cavity lies a bone that runs from just below the eye-sockets to the fangs in the upper jaw. Under the nasal cavity the left and right sides are joined by a bridge of bone in which normally the front cutting fangs are set. In the human being, on account of his "flat snout" and "stunted fangs," the intermaxillary bone is very much shrunk, because of which it is no longer seen as a separate bone, but appears continuous with the rest of the skull.

Goethe succeeded in showing the existence of this bone above the cutting teeth in human beings. For him, however, this was not taken as a particular anatomical detail; rather, it

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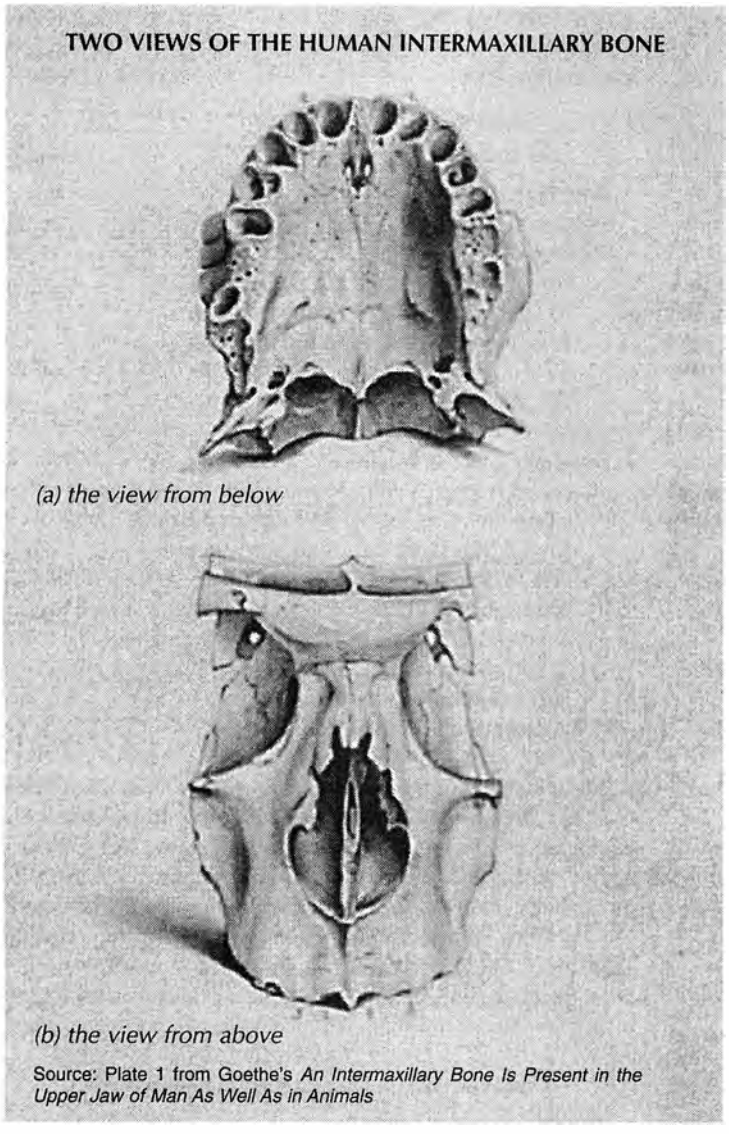
Ralf Schauerhammer is an editor of the German-language science magazine Fusion, *a computer specialist, and an organizer with the LaRouche political movement in Germany. This article first appeared in the Summer 1999 issue of* Fusion, *and was translated into English by Paul Gallagher and David Cherry.*



Source: Plate 1 from Goethe's *An Intermaxillary Bone Is Present in the Upper Jaw of Man As Well As in Animals*

Siftung Weimarer Klassik, Goethe-und Schiller-Archiv (photo: S.Geske)

was his intervention in a vehement debate on the human form. The apparent lack of an intermaxillary bone was seen as a proof for the distinction between men and beasts. Let him, to whom this sounds silly, be reminded that in the field of genetics today, the same question is treated with the same incompetence in the submicroscopic sphere, in which man is reduced to determination by individual genes.

For Goethe, it is clear: Man is man in every bone, and today he would say in every gene as well. The special characteristic of Goethe's work is not the discovery of the bone itself, but that Goethe developed and brought to his discovery a method of research that was entirely new at that time, comparative osteology.

Goethe did not examine the human skull in more and more detail, in order to find this bone at long last; rather he began by "forgetting" the human skull and examining first all possible animal skulls—the skull bones of elephants, tigers, apes, various birds, fish, and lizards. He sought constantly to recognize the law of development of these bones. Not of development in time, in which one bone originated from another; rather, he sought the timeless harmony, through which are expressed the function and proportion of the various bones of the skull. Through this study he reached an "experience of the higher type"; he recognized "a higher principle" which, from that point on, allowed him, by a glance at the skull of an animal that he had never seen before, to recognize how the intermaxillary bone had to look in relation to the form of the skull. Indeed, he was finally able to invent an entirely new animal, and lawfully and correctly form these bones for it. After he had so trained his mind's eye, he turned anew to the human skull, within which no one to that time had been able to find the intermaxillary bone. And now he "saw" it clearly, and knew exactly where the finest grooves and sutures separate it from the rest of the skull. Later he would generalize this "comparative" method and introduce the idea of metamorphosis to natural science.

This new method of research was no chance accident; it sprang from Goethe's understanding of the universe; God reveals himself in nature, not in received holy writings or in other ways knowable only to those initiated in the secrets. Each being, even the smallest worm, is perfect, and an image of the entire creation. Mankind is a part of creation; man is its highpoint, for as the being gifted with reason, he can know the laws of the creation.

And so Goethe, on September 17, 1784, transmitted his discovery to C. von Knebel, with these splendid words:

> Here I send to you at last the treatise upon the realm of the bones, and request your thoughts on it. I have refrained until now from disclosing the result—upon which Herder has already expounded in his *Ideas*[2]—that one cannot find the distinction of mankind from the beasts in any particular alone. Rather, man is related to the animals in the closest possible way. The concordance of the whole makes each creature what it is, and man is man through the form and nature of his jawbone just as well as through the form and nature of the last joint of his little toe. And so, again, is every creature only a tone, a shading of a great harmony, which, as well, one must study complete and whole, or else each individual is a dead letter. From this viewpoint this little piece is written, and that is really the interest that lies hidden within it. . . .

One must always search for the "great harmony" of creation, of which each creature is "only a tone, a shading." That was Goethe's way of proceeding. In contrast to this, what a flat and linear way of thinking, underlies the Darwinist thesis of "development," with its battle cry: "man descends from the apes!" It springs from a one-dimensional way of thinking, which Goethe rejected. In spite of this, Goethe was made by the "German Darwin" Ernst Haeckel, into a forerunner of Darwin:

Among the great natural philosophers, to whom we owe the first grounding of an organic theory of evolution, and who share next to Charles Darwin in originating the theory of the origin of species, Jean LaMarck and Wolfgang Goethe stand foremost.

The extreme empiricist Emil DuBois-Reymond rightly recognized, on the contrary, that Goethe would have "turned away shuddering" from Darwinism.[3]

Goethe saw a nature changing itself in every moment according to harmonic laws, a process in which man participates. A fixing or "conservation" of nature and a dominant and destructive contradiction between man and nature, often claimed today, was unimaginable for Goethe. The constantly renewing and forming Harmony of Creation is the opposite of the belief in a Romantic "shepherd's idyll" or a one time "Golden Age," a revelation which we can only believe in by received authority. For Goethe, nature always creates itself anew according to harmonic laws; mankind, in spite of all weaknesses, is good in principle, and the universe is knowable for him. Because of this, one studying the world can know it ever better and more deeply; but also, the natural powers of mankind can be trusted. For in this Goethe was at one with Schiller: "What hides its reason from wisdom and art, / That fancy will find in the childish heart."[4]

Metamorphosis of Plants: Path to the Original Phenomenon

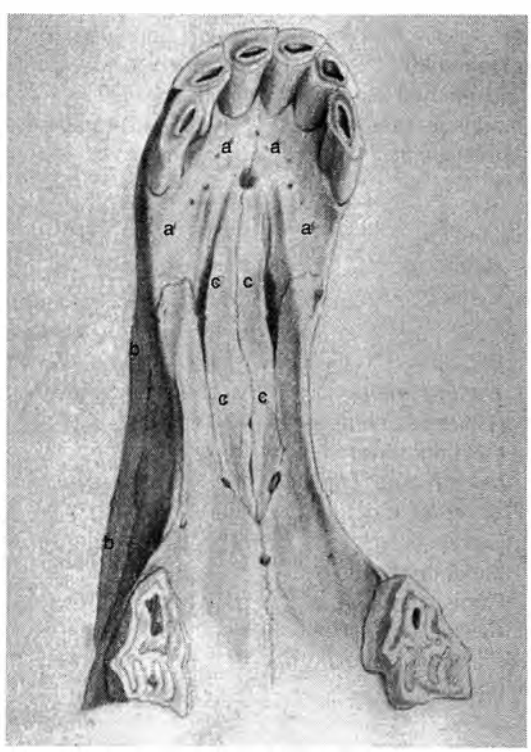
If one further develops Goethe's scientific research method, with which he discovered the human intermaxillary bone, applying it to the entire plant world, then one comes to the concept of the "original plant" and finally to Goethe's concept of "original phenomenon" in general. Thus the idea of the original plant arises so immediately from the study of the most various plants, that Goethe appeared to obtain it as an entirely empirical result of observation; indeed initially he expressed himself almost as though on a "journey of discovery" to the original plant. During his Italian journey it became clear to him that the original plant is an idea—although he had never used exactly this word in this way before his encounter with Schiller, and even later would not have used it. The original plant is a principle of form, a kind of building plan, a creative principle according to which all the parts of plants are formed.[5]

It is also not accidental that this deepening of Goethe's method of research was accomplished at the time of his Italian journey. The change in his way of thinking stood in connection to Goethe's crisis of life at that time. He had come to Weimar as a favored child of fortune, in whose lap had fallen the call to national poet. In the farsighted circles there, he had applied himself with élan to changing and bettering the world in definite ways. Ever more tasks of state were assigned to him. From the standpoint of a "normal career," everything seemed on a wonderful course, yet he was frustrated and fled to Italy. He must have recognized that society, and especially the nobility, was hopelessly corrupted, and that even the best and most well-intentioned effort could lead to no lasting improvement. Let us keep in mind: It was the time of the American Revolution, but of the French Revolution as well.

Goethe had to achieve depth for himself, in order once again to achieve new creative strength for the future. Now he recognized the meaning of the highpoint of Greek culture, not as an object of historical investigation, but as the source for the necessary future renewal. For natural science, that meant that he must not only further develop his method, but also critically observe human reason and the cognitive capability. He no longer concentrated only on the act of knowing, but demanded that the creatively thinking human being must observe his own thought over his shoulder, "with irony."[6]

How necessary this subjective distance must have been for Goethe, can be recognized in the way that he was straightaway obsessed at this time by the idea of the original plant. He reported on his sojourn in Palermo, for example, on April 17, 1787:

> It is a true misfortune when one is followed and pursued by many kinds of spirits! I went early today to the public garden with the serene and firm design of pursuing my poetic dreams, but before I was aware of it, I was seized by another ghost, which has been sneaking after me these days. The multitude of plants, which I was otherwise accustomed to see only in bowls and pots, and indeed for the greater part of the year only behind glass windows, stand here fresh and happy under the free heavens, and by perfectly fulfilling their destiny, they become more intelligible to us. At the sight of so many kinds of new and renewed realms, the old caprice came back to me: Could I not make discovery among this throng, of the original plant. For there must surely be some such thing! Wherefore would I otherwise know this or that creation to be a plant, if they were not all formed from a model.



Skull of a horse showing (a) Corpus, (b) Apophysis maxilaris, and (c) Apophysis palatina.

Source: Plate from Goethe's *An Intermaxillary Bone Is Present in the Upper Jaw of Man As Well As in Animals*

A little later, he wrote triumphantly in a letter to Charlotte vom Stein from Rome:

> Tell Herder that I am extremely close to the secret of the generation and organization of plants, and that it is the simplest thing that one can imagine. . . . With this model and with the key to it, one can then endlessly invent plants that must be consistent, that is, if they do not already exist, they yet could exist, and not being some kind of painter's or poet's shades and similitudes, but having an inner truth and necessity. . . . The same law will lend itself to be applied also to all other living things.

But then what is the "original plant"? Although this original phenomenon stood before Goethe's eyes as a formed idea, he made no picture of it. As we will see later, regarding the first meeting between Goethe and Schiller, he occasionally supported his explanation of the idea "with some penstrokes," and there are some drawings left by Goethe from which one can conclude how those penstrokes may well have looked. We see there a node with a leaf, as well as an unfolding of the plant in a series of such nodes, and finally the contracting formation of the bloom, which, repeated in the tiny space of the seed, lets the plant arise anew from the cotyledon.

But Goethe has given us the most beautiful portrait of the original plant in a poem, a love poem which allows the original plant to arise as a figure before our inner eye. Goethe wrote "The Metamorphosis of Plants" on June 17-18, 1798, for his wife-to-be, Christiane.

Goethe and Alexander von Humboldt

How decidedly Goethe's concept and method had influenced natural science at that time, is made clear by the way Alexander von Humboldt, certainly the greatest natural philosopher of that age, took up this concept and carried it further. In 1805, Humboldt dedicated his book *Ideas Toward a Geography of Plants,* to Goethe, and he had Bertel Thorvaldsen illustrate a dedication page, which depicted Goethe in the form of an Apollo who unveiled Nature with his "Metamorphosis of Plants."

In fact, this dedication was neither lip-service nor a simple gesture. In May 1806, after his return from his famous research and exploration journey through South America, Alexander von Humboldt wrote a letter to Caroline von Wohlzogen (1762-1847), in which he reflected on his stay in Jena:

> In the forests of the Amazon River, as by one breath inspired, from pole to pole, only a single life is poured out in stones, plants, and animals and in the human being's swelling breast. Everywhere I became filled with the sense of how powerfully those relationships from Jena had worked upon me, how I had been uplifted by Goethe's insights into nature, and arrayed, as it were, with new sense organs. . . .

This recollection refers back to April 1797, when von Humboldt spent a week in Goethe's home on the *Frauenplan.* They performed experiments in which Schiller also participated.

Humboldt adhered to the same fundamental principle as Goethe, to be sure from a different standpoint, in his *Ideas Toward a Physiognomy of Growth.* The development and construction of the 16 fundamental physiognomic forms, which appeared for the first time at the end of his *Ideas Toward a Geography of Plants* and been treated in greater detail in *Views of Nature,* were a further development of what Goethe had set forth on the original plant and metamorphosis.


J. W. von Goethe

Herzoglich Sachſen-Weimariſchen Geheimerath

Verſuch

die Metamorphoſe

der Pflanzen

zu erklären.

Gotha,

bey Carl Wilhelm Ettinger.

1790.

The first edition (1790) of Goethe's Metamorphosis *(left). The full title is,* An Attempt to Explain the Metamorphosis of Plants. *Some of Goethe's illustrations are at right.*


A node with leaf


Series of nodes


"Contracting" formation of the blossom

Further evidence of the close intellectual relationship of Alexander von Humboldt and Goethe the natural scientist, is found in the introduction to Humboldt's masterwork, *Cosmos,* in which he quoted in detail from the essay, "Fragment on Nature," published by Goethe in 1783:[7]

> Nature! We are surrounded and embraced by her, incapable of leaving her and incapable of going deeper into her. Unasked and unannounced she takes us into the circle of her dance, and carries us forward with her until we are wearied and fall from her arms.[8]
>
> She creates ever new forms; for what is, never was before; what was, shall never come again—all is new and yet the old.
>
> There is an eternal living, becoming, and moving in her, and yet she never comes nearer [to us]. She is always transforming herself, and there is not a moment in which she stands still. Staying, she has no word for it; and standing still, she has placed her curse upon it.
>
> To each she appears in a different form. She conceals herself in a thousand names and terms and is always the same.

Not only in the introduction, but over and over again in Humboldt's *Cosmos* there are passages that express a "mutual agreement of fundamental outlook" between Goethe and Alexander von Humboldt. For example:

> In the manifoldness and in the periodic changing of life forms, the original secret of all creation is incessantly renewed; I ought to have said: that problem of metamorphosis, so happily treated by Goethe, a solution which answers the requirement of unlocking an ideal way of tracing back the forms to reach a certain archetype.

Schiller's Friendly Admonition

As already mentioned, the first personal discussion between Schiller and Goethe, on July 20, 1794, in the Society for Natural Science at Jena, also dealt with metamorphosis, and as Goethe, with a few penstrokes, "let arise before the eyes" of Schiller his original plant, Schiller objected: "That is not experience, that is an idea." Goethe described this "first acquaintance with Schiller" 23 years after the meeting, from memory, in this way:

> We reached his house; the conversation drew me within; there I presented the metamorphosis of plants in a lively manner and with a few characteristic penstrokes let a symbolic plant arise before his eyes. He heard and beheld it all with great involvement and interest . . . but when I was finished, he shook his head and said, "That is not experience, that is an idea." I stopped short, somewhat annoyed: . . . the old rancor wanted to rouse itself; but I pulled myself together and replied: "I can be glad that I have ideas without knowing it, and even see them before my eyes." Schiller, who had much more worldly wisdom and good manners than I . . . replied as an educated Kantian; and as my stiff-necked realism gave many an occasion for lively disagreement, much was fought over and then a deadlock reached; neither of us could consider himself the victor, each held himself invincible . . . nevertheless, the first step was taken.

This strife over the concept of "the idea" was essential for the "intuitive, graphic" way of thinking of Goethe, and we have already noted how Goethe later approached Schiller's concept.

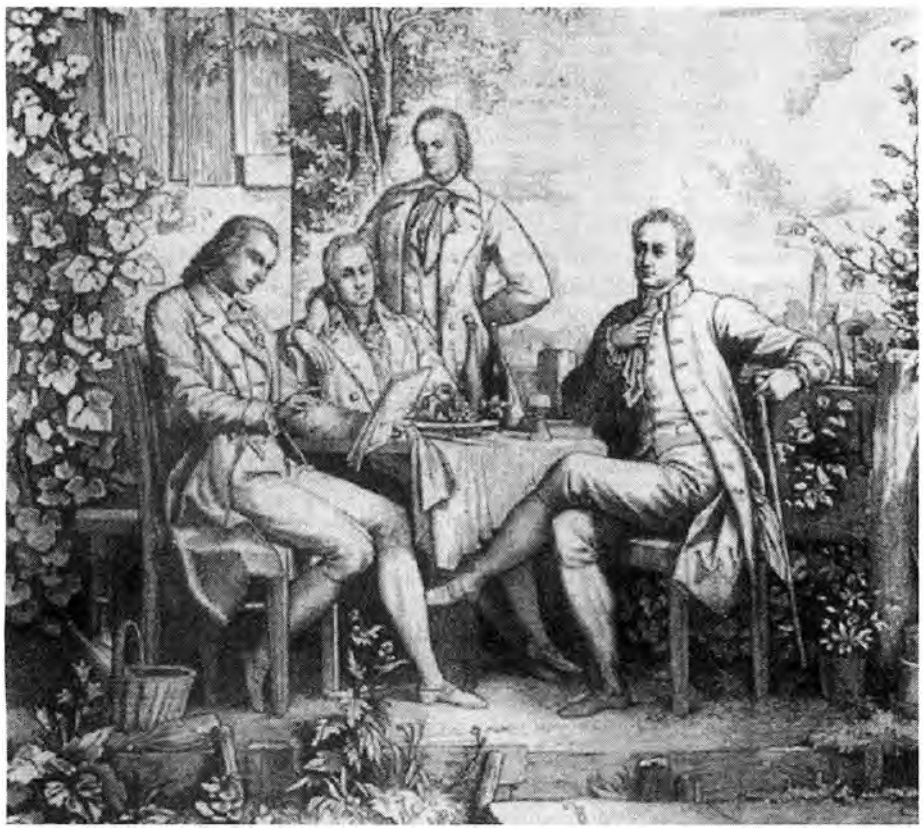
From their correspondence we can conclude that Schiller and Goethe discussed natural science very intensively during the first days of their personal acquaintance. In August 1794, Goethe added as an appendix to a letter, his essay, "How Far the Idea, that Beauty is Perfection with Freedom, May be Applied to Organic Beings." In his letter of reply, Schiller referred to a correspondence between himself and Gottfried Koerner one-and-a-half years earlier. This reference was to the so-called "Kallias letters," in which Schiller had written to his "indulgent friend" on the idea of beauty as freedom in its visual appearance.[9]

The next important phase of the cooperation between Goethe and Schiller on questions of natural-scientific method, doubtless came at the beginning of 1798. At that time, Goethe dedicated himself intensively once again to the theory of colors, and pressed Schiller immediately to help him with the clarification of epistemological questions. On January 9, 1798, Goethe wrote to Schiller:

> Meanwhile, in these colorless and joyless hours I have again taken up the study of colors. . . . Now, too late, I see for the first time how foolish the undertaking was. . . . For even now, when I have worked through it so extensively, it still requires a very great effort to bring my material to a pure description. . . . I append a little essay, which could be about four or five years old; it will certainly entertain you to see how I saw the thing at that time. . .

The "little essay" is a reference to his piece, probably from 1793, titled, "Experiment as the Mediation Between Object and Subject," from which it is worthwhile to cite some passages here:

> As soon as man becomes aware of his surroundings, he looks at them with respect to himself, and rightly so. For his entire fate depends upon whether they are pleasing or displeasing to him, whether they welcome or repulse him, whether they are useful or injurious to him. This entirely natural way of looking at things and judging them appears as easy as it is necessary, and yet man is laid open to a thousand errors by it, which often confound him and embitter his life.
>
> A much harder day's work is undertaken by those, who with an energetic drive, strive after knowledge of the workings of Nature in themselves, and to observe them in their relations to one another: for they soon miss the measuring rod of pleasure and displeasure, of embrace or repulsion, of gain or loss; for they must forswear it entirely; they must seek out and investigate creatures as indifferent and in some way divine—what



Wilhelm and Alexander von Humboldt (center) visit Goethe (right) and Schiller in Jena, 1797.

is, and not what pleases. . . .

When we intentionally and by design repeat former experiences by our own actions or with the concurrent participation of others, and again produce the phenomena that have arisen partly by chance and partly by art, we call this an experiment.

The value of an experiment consists for the most part in this: that it is able to produce repeatedly the same conditions with a known apparatus and the requisite skill, as often as the given circumstances are brought together. . . .

But as valuable as such an experiment may be when considered by itself, it only receives its worth through combination and conjunction with others. But to combine and conjoin even two experiments that have some similarity, involves more rigor and attentiveness than even acute observers have often demanded of themselves. . .

Hence one can never be sufficiently on guard against drawing conclusions too quickly from experimentation: for it is in the passage from empirical experience to judgement, from experience to application, that, as if at a mountain pass, all man's internal enemies ambush him; imaginative power, impatience, hastiness, self-satisfaction, levity, inconstancy; and whatever the entire throng with its retinue might be called, they all lie in the background and, unexpectedly, overpower the worldly man of business as well as the quiet observer who appears secured against all passions .

. . . That is, I dare to claim that *one* experiment, in fact the conjunction of several experiments, proves nothing; indeed, that nothing were more dangerous than to wish to confirm some thesis directly through experiments, and that the greatest errors have arisen precisely through not comprehending the danger and insufficiency of this method. . . .

For it is just so, Goethe wrote:

In living Nature nothing occurs that is not in connection with the whole, and when experiences *appear* to us to be isolated, when we have regarded experiments only as isolated facts, we do not therefore say that they *are* isolated; it merely poses the question: how do we find the interconnection of these phenomena, these occurrences? . . .

Therefore, when we have comprehended such an experiment, had such an experience, we cannot investigate carefully enough, what borders on it *immediately,* what follows upon it *next.* It is this that we have to look at, more than that which *applies or pertains to* it. The *variation of just such an individual experiment* is the proper mission of the scientist. . . .

Such an experience, composed of several others, is obviously of a *higher type.* It represents the formula under which countless individual cases of reckoning can be expressed. I hold it the highest duty of natural scientists to work away on such experiences of the higher type. . . .

One sees the distinction from a mathematical demonstration, which leads its original elements through so many relationships, and from the proof which a shrewd orator can develop by argumentation. Arguments may contain entirely isolated relationships and, nevertheless, through wit and imagination, be made to converge on *one* point. . . . So also one can assemble the individual experiments like arguments, in favor of a hypothesis or theory, and produce a proof that more or less deceives. . . .

Schiller answered Goethe on January 12, 1798, supporting Goethe's basic concept. But Schiller also clearly imparted to him, along the way, the friendly advice that he should not, on his side, "limit the powers of thought too much by means of the object"—advice which Goethe, especially in his treatment of the theory of colors, did not sufficiently take to heart. We will soon recognize more particularly that the passage quoted

above on "the experiment as mediator" arose, above all, against the background of Goethe's encounter with Newtonian method.

Schiller replied:

> Your essay contains an excellent image and account of your experience with natural history, and touches upon the highest concerns and requirements of all empirical reason, while it only seeks to provide the rules for one single transaction. I will read through it with care and think it over, and then send you my comments. It is very enlightening to me, for example, how dangerous it is to seek to prove a theoretical principle directly through experiments. It seems to me that this agrees with another philosophical warning, that one ought not to prove his theses through examples, because no principle is like the example. The opposite method entirely misses the essential difference between the world of Nature and the world of reason; indeed it elevates all of Nature, while it simply lets us find her image in things, never the other way around. In general, a phenomenon or fact, which is something usually multiply determined, can never be adequate for making a rule that is simply determining. I hope that you will favor developing the principal thrust of this essay for its own sake, independent of the investigation and experiences for which it serves as an introduction [here]. You would give important indications of a purer and more rigorous separation of practical experience and theoretical usage; one would be brought to the point of convincing himself that only thereby can science be broadened; that on the one hand, one follows the phenomenon without any claim of a preexisting unity, considers it from all sides and simply seeks to grasp Nature in her breadth and scope—on the other hand (and only if that first one is made secure), one favors the freedom of the imaginative powers, one lets the synthetic capacity experiment with it at will, with the proviso that the imaginative power seek to construct something only in its own sphere and never in that of fact. For it seems to me that up until now, natural science has erred in two opposing ways: at one moment Nature has been narrowly constrained by theory, and at another, the powers of thought tend to be too much limited by the object. Both must have justice if an empirical reason is to be possible, and both can have justice if a strict critical police separates their fields. As soon as the freedom of the theoretical capacity is favored, it cannot fail, and experience teaches that the manifoldness of the kinds of conceptualization, through which they mutually limit and more often elevate each other, makes good the harm done by the despotism of a single one.

The Theory of Colors: Goethe's Battle Against Newton's Non-Soul

The most extensive portion of Goethe's natural science research, judging by the number of published pages on the various themes, concerned the theory of colors. And none of his works has been so praised and damned. As we have seen at the outset, Goethe remained almost entirely isolated in his view of things. There were two grounds for this. First, his essential point of criticism of the ruling empirical method, which Goethe identified with the Newtonian school, was not understood. The reason for this was explained in the introduction. But it was not only the thickheadedness of his contemporaries which isolated him. For, Goethe did not succeed in developing a workable alternative to this empiricist method, an alternative which one could confidently embrace in natural science. Ironically, that is because, precisely in the sphere of sight, the "intuitive" method of the original phe-

Goethe visits Schiller at home. The two poets conducted an intensive dialogue on questions of natural science.

nomenon, so successfully developed and applied in biology by Goethe, presses on its limits. This explains why Alexander von Humboldt, who so publicly welcomed Goethe's work in the sphere of biology, strictly refrained from public comment on Goethe's theory of colors.[10]

Let us first look at how Goethe proceeded with the theory of colors, and why.

The Original Phenomenon of Color Theory

"Colors are actions of light; actions and modifications." So wrote Goethe in the Foreword to the first edition of his *Theory of Colors* in 1810. He continued:

> In this sense we can expect from them disclosures about light [itself]; colors and light certainly stand in the most exact relation to one another, but we must think of them both as related to the entirety of Nature; for it is she entirely, who seeks to become manifest especially through the sense of sight.

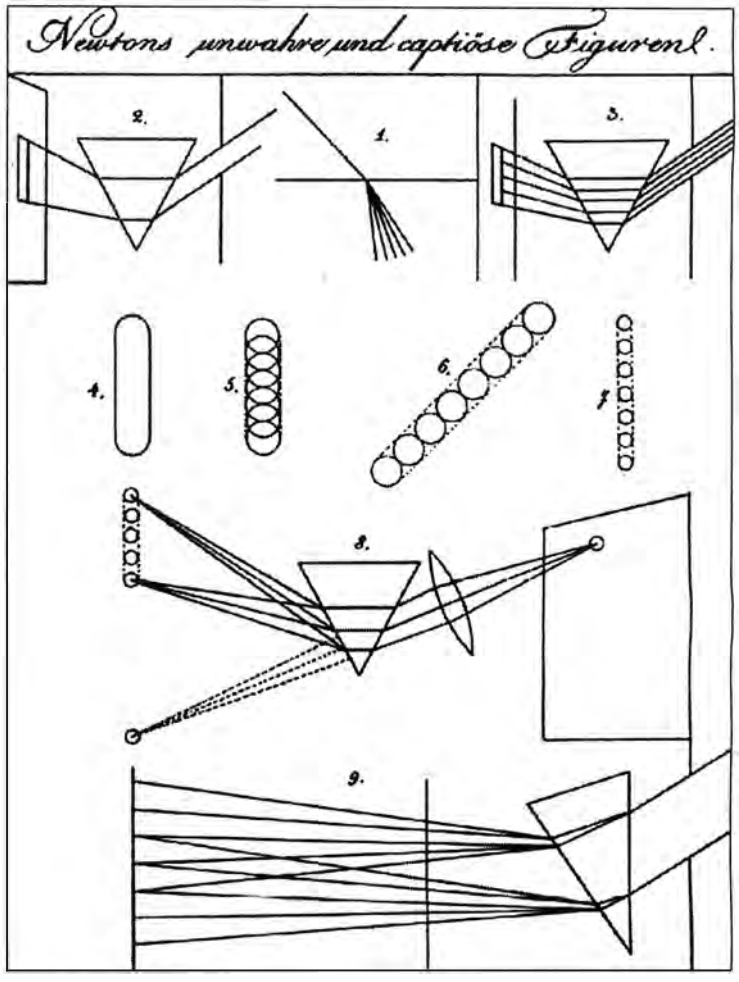
And in the subsequent Introduction to his *Theory of Colors*, he went on:

> The eye has the light to thank for its being. From equivalent auxiliary organs of animals, light calls forth an organ to become like itself, and the eye is constructed with respect to light and for light, so that the inner light meets the outer. This reminds us of the old Ionian school, which always repeated so significantly that only by like will like be recognized; as also the words of an old mystic,[11] which we might express in the following way in rhyme:
>
> Were the eye not like the Sun,
> Then light, how could we see it?
> Were God's power not in every one,
> The divine, how could we enjoy it?[12]
>
> This immediate relationship between light and the eye will not be denied by anyone; but to think of them both together as one and the same is more difficult. It is easier to grasp if one asserts that in the eye abides a light at rest, which is activated at the slightest opportunity from within or without.

Goethe thus drew the boundary between the spiritual "power of imagination" and physical "appearance," differently than does "objective" empirical science. The "inner" light "rests" in the eye and makes possible the physical seeing of the "outer"—that is, of physical light—only through an active transaction, to which it is moved through inner or outer stimulation. Consequently, in his investigation of light and colors, Goethe goes from the eye outwards.[13]

> Thus we observed colors first insofar as they belong to the eye, and depend upon its action and reaction; they further drew our attention in that we become aware of them by means of colorless media or with their help [that is, in particular, experiments with prisms, which Goethe wishes to have investigated only secondarily]; but lastly they were noteworthy to us in that we were able to think of them as belonging to objects. We called the first physiological, the second physical, the third chemical colors. . . .
>
> At present we state only this much, that light and darkness, bright and dark—or if one would employ a general formulation, light and absence of light—are required for the production of color. Next to the light arises a color, which we call yellow, another next to the darkness, which we designate with the word blue. These two, if we mix them in their purest condition, in such a manner that they hold exactly the same weight, bring forth a third, which we call green. But each of the first two colors can also produce a new phenomenon in itself, in that it may condense or darken. They contain a reddish aspect, which can intensify to a high level, such that one can hardly recognize in them the original blue and yellow.

This "intensification" of, respectively, yellow or blue into red, was later designated by Goethe "one of the most important



With these nine examples, Goethe demonstrated what he called, the "untrue and captious figures of Newton."

phenomena in the study of colors, in which we experience entirely comprehensibly, that a quantitative relation or proportion brings forth a qualitative impression upon our senses."

Again in the study of colors, Goethe searched for an original phenomenon. He thought thus: Empty space is absolutely transparent. If one conceives of this space filled in some way with matter, of which nonetheless the eye can discover no distinction, this is "transparency itself," which "is already the first degree of opacity." From there, it progresses continuously to white, which is "completed opacity." The interaction between opaque media, and light and darkness, produces all physical colors as "derived phenomena" of this "original phenomenon," or of the two aspects of the "original phenomenon"; that is, the interaction of opacity with light or with darkness. Colorless light seen through an opaque medium appears yellow, and with increasing opacity yellow-red, and further, to ruby red. Darkness, seen through a medium illuminated by incident light, appears blue, and with the smallest degree of opacity, violet.

Thus the Sun at midday, for example, appears (because of less atmospheric opacity) yellow, and at evening (with greater opacity) red. On the other hand, the darkness of space, seen through daylight, appeared to him blue, which is increasingly intense as the atmosphere becomes clearer.[14]

And what about color phenomena that arise from the refraction of light rays "with the help of colorless media?" Indeed, the Newtonian theory traces all colors back to the differential refraction of light. Goethe describes with great immediacy, in the "Confessions of the Author" in his *On Color Theory* (1810), how with a glance through a borrowed prism, he saw suddenly and unexpectedly a thin edge of color appear only on the borders, and not, as he had expected, over the entire screen. He said that he had thereby "immediately, as by an instinct," recognized "that the Newtonian theory was false." One cannot entirely believe this dramatic story, because he indicated in the same place, through his remark about his memoranda on the blues of the heavens, that he had already come to an entirely different theory of color than that of Newton, one in which a decisive role was played by the polarity between light and darkness, from which blue might be distinguished "only as a matter of degree." The "disillusioning" look through the prism at the white screen was meant to clarify to the reader his theory of colors, by which white light produces the different colors only at boundaries or through opacity.

Proceeding from his concept that color derives from the polarity between light and darkness, the essential phenomenon for Goethe is the "split spectrum." This is what we see when light from a wide source, like a window, passes through a prism. (It is not observed in the classic Newtonian experiment, where the light derives from a narrow opening.) The rainbow of light projected by the prism onto a white background is split into two parts, the reds and yellows on one side, the blues and violets on the other, with a white band in the middle (see illustration on back cover). Goethe finds this quite natural. We ask the reader to put aside for a moment the Newtonian conceptions learned at school, and try to view it from Goethe's standpoint: On one side of the split, the "light side," we see yellow and then, moving inward, its "intensification" to red; on the other side, the "dark side," appears blue, together with its "intensification," violet. Green arises, only as a mixture of the two, when the slot or aperture from which the light is coming is narrow enough for the two halves of the split spectrum to meet.

Newton looked upon this same phenomenon quite differently, proceeding from his hypothesis that the prism decomposes the white light into the seven colors which, he believed, are its constituents. He explains the white central portion of the split spectrum, which occurs when the light originates from a wide aperture, as resulting from the bending of decomposed rays coming from the outer portions of the prism towards the central part of the image. Since these rays are of all different colors, they combine again in the center to become white. This does not occur when the source of the light is a very narrow aperture, however. The narrow beam of light passes through the prism, and is simply decomposed into the seven colors that Newton considers the primary phenomena.

For Goethe, on the contrary, the colors produced by the prism arise through the interaction of light and darkness with the glass of the prism, such that an image becomes "displaced" away from the dark edge to produce a color. This displacement, which he calls the production of a "companion image," works somewhat in the same way that light, in Goethe's view, produces color when it passes through the medium of the atmosphere.

> When the dark edge meets the bright [light source], the broader yellow border moves inward, and the narrower yellow-red border stays closer to the edge. When the bright edge [of the light source] meets the dark one, the broader violet border comes first, and the narrower blue border follows.

But here, Goethe allows a methodological error to creep in, even if the error is of a type that the Newtonian school would not recognize. What he calls a "companion image" is, in fact, an *idea* or *concept*. It is not a real physiological phenomenon which, according to Goethe's way of thinking, is absolutely the only way that an intuition can arise. Thus, Goethe arrived at these companion images, not through a legitimate intuition, but through a conclusion by analogy, which he would have to consider illegitimate. He reasoned in the following way:

If one looks at a white figure, and then closes one's eyes, the eye now sees a dark image. A similar, complementary effect, occurs, if one compares the appearance of a gray figure when it is placed before a white, and then a black, background. Viewed against the white background, the gray figure appears dark and small; against the black background, it appears bright and enlarged. There are thus two complementary effects in black-and-white viewing: first, the inversion of light and dark (which takes a period of time to take effect), and, second, the momentary enlarging or shrinking of the image size, depending on the darkness or brightness of the background.

When it comes to viewing colors, Goethe concluded by analogy, and so came to the colored "companion images." Physiologically, however, there is in the seeing of color only the first effect—namely, the complementary color that appears, after one has looked at a color, and then closes one's eyes. But when colored figures are viewed against a multicolored background, there is no enlarging or shrinking of the image. Goethe also expressed himself quite vaguely:

> By an exact observation of this phenomenon it may be noted, that the images are not sharply delineated from the background, but rather appear with a kind of grey, somewhat colored border, with a companion image.

A "kind of grey border" can be explained through the seeing of black and white, but an actual colored "companion image" arisen in the "somewhat colored" border, can not. If the companion image is seen merely as a theoretical-logical auxiliary construct, then Goethe's explanation works, but he himself turned directly against this "not evident" kind of explanation, which does not spring from real perception, and therefore he would really have to repudiate his own argument.

Rejection of Newton's *Experimentum Crucis*

Now that we have become acquainted with the principal features of Goethe's theory of colors, and have considered them critically, we must also describe how far Goethe is fundamentally correct in his critique of Newton's manner of proceeding. Goethe turned against Newton's approach, which placed a "complex experiment" at the peak of all investigations. Newton veiled from the reader in this way, his hypotheses on the nature of light, which were assumed implicitly and foisted on the reader. Goethe considered such a way of proceeding dishonest.

He was not the first, however, to issue such a critique. The Jesuit Francesco M. Grimaldi, whose 1666 *Presentation of Optical Experiments* had inspired Newton's optical work, stated in Newton's lifetime, that the *experimentum crucis* (crucial experiment) alone was not sufficient to justify Newton's radical departure from the conception of light and color essentially coined by Leonardo da Vinci. Goethe seized upon this conception of Leonardo's. In addition, the "Newtonian" experiments on the decomposition of light had not really been new, but had been carried out two decades earlier by the Jesuit Johann Marcus Marci von Kronland.[15]

Newton's method in the experimental-deductive manner of presentation of the *Optics,* appearing in 1704, which method Goethe attacked, must be understood against the background of Newton's image of the world and of mankind. Newton's universe is unstable and falls to pieces. In modern terminology, he would have said that it was "entropic." Disturbances between the planets necessarily lead in the course of time to disorder and confusion. Indeed, the whole universe would collaborate in its own degeneration, if the inertia of mass did not stand against this rapid falling apart. According to Newton's worldview, therefore, God must intervene from time to time and bring the universe back into order. Moreover, the necessity of the existence of God, in Newton's opinion, was grounded just upon this necessity of His intervention for this purpose.

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An illustration from a print by Loudan of the young Newton carrying out an experiment with light. His picture of the world would today be called "entropic."

In the same way, Newton's postulated "absolute space" is necessary as the "sensorium" for this wondrous intervention of God. We have Leibniz to thank for having clearly documented this point, through the public debate to which he challenged Newton, and which Newton allowed to be carried out by his scribe Clarke. The central question of this debate was this: Leibniz objected that Newton's God were an imperfect God and a poor "clock-maker," if he must always repeatedly intervene "for repairs," instead of having made the universe, from the beginning, perfect and capable of development. Newton expressly met this objection by saying that God, if He were a true ruler, must also truly rule; that is, He would have to be able to intervene. Newton's God is degraded to an absolute monarch.

Against this, Leibniz insisted that the universe, as also each individual human being, can always become more perfect. God has created the world as the best of all possible worlds; that is, it is capable of creative freedom, because mankind is gifted with reason as "the image of God," and can know the universe and continue the creation. This creative reason of mankind directly proves the existence of God, and not His "wondrous" intervention into the entropic operations of the world machine of Newton's making.

Newton's image of mankind is correspondingly "entropic." The human race is in a process of degen-

eration. The original culture, in his view, was revealed by God to some wise men in a golden age of antiquity. This secret knowledge was preserved, at any given time, by a small number of learned men, and handed down encoded in myths. Newton studied intensively the writings of the alchemist Michael Maier and adopted his views. Newton therefore shaped his own writings to be correspondingly obscure. Against the "principia philosophica" of Descartes, which was hegemonic in his time, he set his "principia mathematica," in which mathematical treatment was intended to discourage creative individuals. The mathematical form of presentation, for Newton, is a facade, by which the true thought process is hidden, and replaced with formal, relatively evident, received knowledge of symbols.[16]

Thus Newton did not use at all the infinitesimal calculus, which at the time would have justified a mathematical treatment of mechanics. Leibniz at that time created this new and productive method, in connection with the physical science of dynamics, an advance beyond mechanics for which he was responsible.[17]

The experimental-deterministic method, as Newton put it forth in his *Optics,* in which he offered it as the basic dogma of the crucial experiment, corresponded exactly to this "mathematical" method of his "principia." Newton hid all hypotheses behind a series of experiments, from which he allegedly allowed the truth to emerge. The crucial experiment stood at the beginning as the axiom from which the rest could be deduced. Goethe's criticism of this misuse of empiricism is presented in the piece already mentioned in the dialogue with Schiller, "The Experiment As Intermediary Between Object and Subject."

The chief point upon which Goethe hangs his discussion of the theory of colors, is this: Before Newton, white light was assessed as an elementary phenomenon of optics and colors as derived. Newton turned this exactly around; for him, white light is composed of elementary colors. Today we say monochromatic light is elementary, and understand by "monochromatic" the numberless singular frequencies at which electron transitions in matter radiate electromagnetic energy.

Such an approach has been possible only since Joseph Fraunhofer's work in 1815, which established these spectral colors in the continuum of sunlight. Newton's definition of "elementary" colors had nothing whatever to do with this, however. From the crucial experiment, he concluded, among other things, that there are two kinds of colors, simple and composite. The elementary colors are seven: red, yellow, green, blue, violet, orange, and indigo. Visible changes in these colors, according to Newton, can be produced by the mixing of different rays. And even the primary colors can be called forth through the combination of different rays, whereby the mixture of two spectral colors yields the one which lies between them.

It is, in fact, not very logical, that Newton's primary colors can also arise through mixing. And Goethe was entirely right in pointing out that Newton's primary colors could be split by a prism into different colors. There is no basis whatever for there to be exactly seven elementary colors, as Newton asserted. Why not three, or twelve, or seventeen? Voltaire, who played a decisive part in the spreading of the cult of Newton in Europe, reported that Newton had chosen seven primary colors because he was inspired to do so by the Jesuit alchemist Athanasius Kircher, and had partitioned the spectrum in correspondence with the seven tones of the musical scale. Had the modern twelve-tone style of music already been current at that time, Goethe would probably have had twelve Newtonian primary colors with which to become roundly annoyed.[18]

If one considers what an unsavory cult around the person of Newton had been promoted since the beginning of the 18th Century, then Goethe's disgust at this "school" becomes all too understandable. One has only to call to memory the famous picture in which Newton, like a medieval saint, sits directly beneath God, with a mirror in his hand, in which God sends him a ray of light. Or the tasteless couplet of the celebrated poet of that time, Alexander Pope,

> Nature, and Nature's law lay hid in night;
> God said, let Newton be! And all was light,

by which the mortal Newton was meant to be elevated above the gathered creation of the universe.

Goethe's criticism of the dominant Newtonian school in science is just, and is also just in the form advanced by him: He refused on principle to lower himself to that methodological level.

But now the following question arises: Admitted that Goethe was right in his radical assertions; admitted that he was, in fact, the only one who knew "the truth" in the "difficult sphere of color theory"; is his method then a fruitful one for the future of natural science? If so, it would be infinitely more valuable than a justified critique of an obviously wrong line of development, and extremely relevant for today, exactly as Goethe's contemporaries and their descendants thought.

I have come to the conviction that this question must, in the last analysis, be answered in the negative, and in the following, will seek to explain the self-limitation in Goethe's research method that is responsible for this negative answer.

Kepler, the Original Phenomenon, And Schiller's Admonition Again

We ought to take up Schiller's friendly admonition to Goethe once more, and this time, indeed, against the background of some thoughts of a great natural scientist, for whom thoughts of the harmonic whole of the universe were at least as fundamental as for Goethe—the founder of modern astrophysics, Johannes Kepler. In his principal work, *The Harmony of the World,* Kepler occupied himself, in the Foreword to Book IV, with how harmony can in general be experienced and knowable. He said:

> But if we now see it as our task to discover the harmonies in Nature and in the motions of the heavens, the mass of philosophers think immediately, at the first mention of harmony, of sounding tones, a music of the stars perceptible to the ear . . . [and seek] reasons . . . why the heavenly music cannot be heard on Earth.

Instead of which, said Kepler, one must begin with the question: "To what species of things is the nature or essence of the harmonic, and the knowledge of it, to be assigned?" Then, in the first chapter of Book IV he explained that one "must distinguish between the harmony which is sensuous or analogous to the senses, and the harmony which is freed from all that is sensuous, and which is pure." For one

> easily perceives that one may not define the nature of harmony only through sensuous things, for example through tones or rays from the stars. For the tone is one thing, the ordained ordering of different tones is another. . . . Different tones may thus exist; but if between them a defined ordering does not exist, such that they are defined by definite proportions, and thus by some mathematical relations, then no harmony will exist between the tones. . . . The ordering goes thus in step with quantities, and especially with number. . . . Thereby number is not, in a material respect, within things in itself, unless numbering reason intervenes. Thence number first comes to be . . . the concept of multiplicity from particularities. In the same way, the ordering of tones and of other sensuous things, of which we treat here, is also nothing other than the plurality of tones, unless reason steps in, which compares different tones with one another according to pitch.

Before the sensuous experience of harmonic laws is possible, some inner harmony must be established in the mind, because otherwise only a chaotic swarm of sense impressions would be perceived.

In his work *Tertius Interveniens,* Kepler described the process of knowledge still more clearly:

> The creature in its activity imitates, unconsciously or consciously, instinctively or according to reason, the Creator; the Earth [does this] in forming the crystal; the plant with its formative ability in building and ordering its leaves and flowers; mankind in its forming activity. And all this doing is like the play of a child—without intention, without goal; out of an inner drive, out of the joy of building and shaping out, so that the eye takes delight in what arises, and the observing mind finds itself again and recognizes itself in what it has created. As God the Creator played, thus Nature also, as His likeness, learned to play, and surely the very play that He had played for her.

And finally the following, which is especially relevant to Goethe's statements on the theory of colors:

> If the mind had never been participant in an eye, it would demand an eye for itself for the grasping of things lying outside itself, and prescribe the laws—derived from itself—for the eye's construction (provided the mind were pure and healthy and without hindrance: in other words, that it were only what it is). For the knowledge of quantities, innate in the mind, specifies how the eye must be, and thence is the eye made so, because the mind is made so, not the other way around. But why so many words? Geometry, belonging to the divine mind from eternity, before the origin of things, [being] God Himself (for what is in God, that is not God Himself), has provided God with the original forms for the creation of the world, and, together with the image of God, it has been passed on to mankind; thus, geometry is not taken into the inner self for the first time through the eyes.[19]

Johannes Kepler: "For the knowledge of quantities, innate in the mind, specifies how the eye must be."

Kepler calls to Goethe that it is not only the physical light which makes the eye and can explain how the eye, such as it is, functions; the "spiritual" light may not be hidden under a bushel! "For the knowledge of quantities, innate in the mind, specifies how the eye must be." For Kepler, the essential quality for gaining knowledge of the archetypes of creation—"which through the Creation pass from God to man"—is the creatively playful mind.

That is an entirely decisive shift of emphasis. While Goethe always proceeds primarily from the capability of knowing from sensuous perception, presuming it as given, Kepler asks himself how sensuous perception, in general, may be possible at all, and comes to the conclusion that the harmony in Nature can be perceived only through the freely playing creative spirit, which develops concepts of harmony out of itself, "from within."[20]

That is exactly the point Schiller gave Goethe to think about in his friendly admonition, in answer to the piece, "The Experiment As Intermediary": namely, that one should not "limit the powers of thought too much, by means of [focussing on] the object." For "[a]s soon as the freedom of the theoretical capacity is favored, it cannot fail, and experience teaches that the manifoldness of the kinds of conceptualization,

through which they mutually limit and more often elevate each other, makes good the harm done by the despotism of a single one."

The lack of "freedom of theoretical capacity" leads at last to stagnation. Goethe fell into this with his "grounding in the original phenomenon"; as soon as the original phenomenon is "found," a "boundary" is reached and the researcher should question no further. But would it then really be found? Would it not have been made only through human reason? In the theory of colors, Goethe in fact went so far as to say, with respect to the finality of the original phenomenon:

> Were such an original phenomenon indeed found, there would still remain the evil that it would be refused recognition as such, that something further will be sought over and beyond it, while right here we ought to have acknowledged the limit of observation. The natural scientist must let the original phenomena stand in their eternal repose and majesty; the philosopher must take hold of them in his sphere, and he will find that, not in individual cases, general rubrics, opinions, and hypotheses, but rather, in the fundamental and original phenomenon, is worthy matter for further treatment and work bequeathed to him.

By what right can Goethe demand this? How should I simply be content with this original phenomenon—which admittedly developed through very serious pursuit and a genius for comprehension in the brain of the man Goethe; how can I let it "stand in eternal repose and majesty?" Nowhere did Goethe leave a comprehensible grounding for it, and further, to do so is not even possible. For each creature, as God's likeness, has "learned to play, and surely the very play that He had played for her." With the "freedom of theoretical capacity" of Schiller's admonition, this play continues without limit.

The fatal consequence of Goethe's self-limitation to his intuitive knowledge, becomes entirely evident when, in the *Aphorisms,* he says:

> Man in himself, insofar as he disposes of his healthy senses, is the greatest and most exact physical apparatus there can be; and this is just the greatest evil of the new physics, that experimentation has almost been separated from man, and Nature is to be known simply in what artificial instruments show; indeed, what Nature can achieve is to be thereby limited and established.

This becomes directly paradoxical when Goethe, who made for himself the claim of universalist, said to Eckermann:

> I have never occupied myself with astronomy, for there one must take refuge in instruments, calculations, and mechanics, which take on a life of their own, and were not the thing for me.[21]

How can one say this, when it is a matter of the knowledge of universal truth? "That is not the thing for me!" Yet, at the same time the same Goethe, through his practical work, lay the foundation for the development of optical glasses, which would later become world famous in Jena, through the production of astronomical and optical "instruments."

To fathom this paradox, one must understand Goethe's attacks on the false "objectivity" of empiricist natural science more deeply than he probably did himself. The subjectivity of science is simply not grounded only upon the "subjective-sensuous" experience of the world; rather, it means above all the "subjective-creative-productive" alteration of the world by mankind. By this means alone, through subjective creative achievements, mankind subjects the Earth to its will—through achievements which, beyond all phenomena won from Nature by observation, produce something completely new. That absolutely does not mean that man destroys Nature with his technology, because, when he is truly creative, he indeed "plays just as the Creator must play," and may only invent his instruments accordingly, in the last analysis under penalty of his own downfall.

The economic scientist Lyndon LaRouche describes this subjectivity of science thus:

> It is a matter of discovery, which subjective type of creative-mental production of thought-objects corresponds to a negentropically accelerated increase of the cultural capability of mankind, . . . It is a matter of the ability of mankind, willfully to improve the capability of the species."[22]

The Russian scientist Vladimir Vernadsky explained exactly this as the decisive question of science, when he said: "Human thought has changed the trend of natural processes in a sudden manner, and has even changed what we call natural laws." In this physical effect of the individual creative mental act, lies the real "subjectivity" of science.

Doing Justice to Goethe

Tragic features come immediately to light when one sees, against the background of history, the bitter words which the old and isolated Goethe flung against the Newtonian school, that he had been the only one who knew what was "right" in the theory of colors. For while Goethe was saying this, Newtonian optics had, in reality, already received its death blow through the work of the young Augustin Jean Fresnel. But Goethe could not recognize this victory over his arch-enemy. Johann Salomo Christoph Scheigger, the only scientist who, at that time, still even discussed questions of optics with Goethe, did not recognize the significance of Fresnel's work; rather, he tried to see in Fresnel's "principles of interference" nothing other than Goethe's "principles of shading."[23]

Goethe made essential advances in individual fields of science, above all in biology. He introduced new and fruitful methods; he was right—as far as he took it—in his critique of the dominant Newtonian empiricist dogmatism, which has so splendidly enraged all empiricists at Goethe to the present day. However, one does him no favor, if today one tries to make him the founding father of a Romantic approach to Nature, instead of coming to terms with him. I have sought to come to terms with him, and I very much hope, thereby, to have done justice to this great man.

Notes

1. Max Weber's essay, "Roscher and Knies and the Logical Problem of Historical National Economy." In it he characterizes natural science by reduction to "exact measurable quantities," through which it approaches "potential judgments of general validity." The sciences of the mind, on the contrary, concentrate on the "qualitatively characteristic singularity" of things and lead to the "individual concept of the object of historical meaning." In our century, this rift between science of the mind and of the natural world would be broadened even into a distinction between two different cultures, as Charles Percy Snow claimed in *The Two Cultures and the Scientific Revolution.*
2. A reference to Herder's "Ideas for a Philosophy of the History of Mankind."
3. Emil DuBois-Reymond, who in his "Riddles of the Universe," claimed on principle the limitedness of the human mind, made such heated public attacks on Goethe's scientific method, that he gave his inaugural address as Rector of the University of Berlin the title, "Goethe and Endlessness," concluding it with this tirade: "Next to Goethe the poet, Goethe the scientist sinks into insignificance," and recommended that "one should at long last let the latter alone, rather than constantly praising him to the skies to the uncritical populace and thus provoking more critical rejoinder. . . . From Darwinism, which comes close to the Kant-Laplace theory through its spontaneous generation, and from the ascent of man out of chaos through the mathematically determined play of atoms from eternity to eternity, . . . Goethe would have turned away shuddering."
4. Lines from Schiller's poem, "Die Worte des Glaubens."
5. Rudolf Virchow writes, in "Goethe as Natural Scientist and Particularly in Relation to Schiller," 1861, page 43, in footnote 1: "How had Goethe changed, when later he portrayed his researches into the animal prototype: 'I strive to find the original animal; that is, in the final analysis: the concept, the idea of the animal.'" *Goethe's Collected Works,* Vol. 36, page 14.
6. A beautiful description of this way of thinking, which considers not only the object, but at the same time the thinking subject, is found in the Foreword (first edition, 1810) to the *Theory of Colors.* There Goethe wrote: "Each look passes into an observation, each observation into a reflection, each reflection into a connection, and so it can be said that we are already theorizing with each attentive glance into the world. But to take this on with consciousness, with self-consciousness, with freedom and, to make use of a daring word, with irony; such a skill is necessary if the abstraction, before which we take fright, is to be harmless, and the outcome of experience, for which we hope, is to be lively and useful." But in the "exact" science of today, irony—thus something ambivalent—has no business.
7. Originally this passage was attributed to Goethe. But it originated with Johann Georg Tobler, with whom Goethe worked closely at the time.
8. Compare this with Schiller's poem, "The Dance."
9. See Schiller's letter to Gottfried Körner, Jena, February 8, 1793.
10. Alexander von Humboldt, while dwelling with Goethe and Schiller in Jena, wrote with amusement to Karl Ludwig Michelet, that he belonged "to the rabble" of professional physicists who were not convinced by Goethe's theory of colors. Humboldt continued: "I have often and very freely spoken with the great man of this, my unbelief, an unbelief which extends to his geological and meteorological fantasies." However, Humboldt did not express this publicly, as a letter to Gottschalk Eduard Guhrauer makes clear: "For I have made it an unbreakable law, never to publish an unfriendly word on Goethe's natural scientific works; so, therefore, I never made mention of, for example, the theory of colors; [and] so may I add the request, not to mention my name in these areas, ravaged but not yet abandoned by the natural philosophers."
11. A reference to Jacob Böhme.
12. Leonardo da Vinci, whom Goethe studied very carefully, said the following in his "Treatises on Painting": "Here, exactly here in the eye, here is formed and colored the character of every part, and all things in the universe are concentrated in a single point. How wonderful is this point!. . . In this small space the entire universe can be reproduced and newly ordered in all its splendor!"
13. For our discussion later, it is interesting to see how Goethe quoted Johannes Kepler respecting the active participation of the eye in the process of seeing. He said that Kepler had also posed himself the question, "whether the basis for the enlargement of the bright image lay in the reaction of the retina, or in the mind." Goethe continued immediately, "However he saw it," because for him the question was fundamentally already decided: The light activates the sense organ and produces the widening of the image. For Kepler, on the contrary, it was a question still to be clarified, how far the organ and the mind were active.
14. According to his theory, for an observer in the mountains, the sky must be violet, because there is less overlying atmosphere. But it is not.
15. Johann Marcus Marci von Kronland (1595-1667). In his 1648 book, *Thaumantis liber de arcus coelesti deque collorum apparentum natura ortu et causis* (The Book of Iris, of the Celestial Vault and the Nature, Origin and Cause of the Perceived Colors), Marci defined the geometric and physical conditions necessary for a rainbow. A generation before Newton, he described how the rainbow's colors were produced by a light beam passing through a prism. He also described the diffraction of light at a thin wire and the blade of a knife, as well as the colors in soap bubbles and in the rainbow. He described all of these phenomena as consequences of the diffraction and reflection of light.

    Newton did not mention Marcus Marci, although he must have known him to be a student of Kircher, and presumably also through the works of Descartes, for Franz Martin Petzel wrote in 1773: "All these [upstanding scholars of Bohemia and Moravia] are surpassed by our Marcus Marci, whose philosophical inventions and penetrating insight are not inferior to the discoveries of the new and old philosophers. Several even claim that Descartes was prompted to build his system through our Marcus's writings and observations, and has borrowed therefrom not a little of his argument, which can be easily seen from a careful comparison of the works of both learned men."
16. The "College of Logic" praised by the Devil in *Faust,* where the "spirit is trained" and "laced up in Spanish boots, . . . so that henceforth it shall more cautiously creep along the road of thought." (The "Spanish boot" was an instrument of torture.)
17. Nevertheless, after the new Leibnizian mathematics had generally succeeded, Newton did not shrink from leading a politically motivated campaign against Leibniz, in which Newton claimed priority in the discovery of the infinitesimal calculus.
18. On Newton's "musical-cosmological speculation," see *Music in History and the Present* (Bärenreiter Publishing Co., 1954, cols. 1812ff.). The "Catholic" Jesuit Athanasius Kircher (1602-1680) and the "Protestant" Rosicrucian Robert Fludd (the Rosicrucians, like Luther, bore the rose and the cross on their coat of arms) were two sides of the same coin. It was decisive for Kircher's career that he came into the circle around Nicholas Claude Fabrie de Peiresc, in Aix. Peiresc himself, like Galileo Galilei, was from 1599 a pupil of Pinelli in the Studio de Padua. Peiresc recognized Kircher's "fantastic" talent in dealing with old and "secret" writings, and through his connections with Pope Urban VIII and Cardinal Barberini, took care that Kircher in 1633 was called to the Jesuit university in Rome, the Collegio Romano. There, he allegedly "deciphered" the ancient Egyptian hieroglyphs. He then found much Egyptian wisdom, parts of Phoenician theology and Chaldean astrology, and records of the Kabbala, Persian magic, and so forth.

    And so it is not surprising that Kircher, in the mid-17th Century, dedicated half of the pages of his work *Oedipus Aegyptiacus* to the theosophical system of Zoroaster (Zarathustra). When, finally, Champollion in the mid-19th Century, with the help of the Rosetta Stone, in fact accomplished the translation of the hieroglyphics, it became evident that Kircher got nothing right except the sign for "water." His entire "science" was an incomparable fraud.

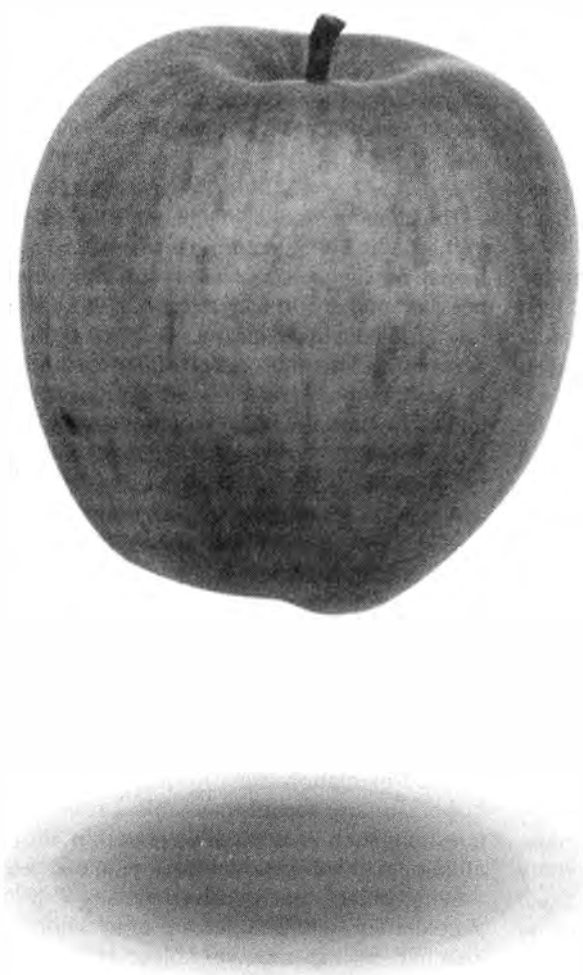
    Another, worse, fraud against science was Kircher's attack against Johannes Kepler. Kepler, in his works on the description of astrophysical processes and events, had repeatedly made metaphorical use of the magnetic effect, which Gilbert had just studied. Kepler always spoke of an effect "similar" to that of a magnet. He also knew the mutual attraction of bodies through the effect of gravity, and described in this connection the phenomenon which we designate today as the effect of inertial mass. The metaphorical use of the magnetic effect by Kepler, is thus unmistakably the description of an effect of rotation, for which he had as yet no exact explanation, and which is definitely not fully identical with the magnetic effect as Gilbert described it.

    But Kircher maliciously claimed that Kepler meant exactly the magnetic force of Gilbert, and from this developed contradictions which supposedly "proved" that Kepler's physics was false. Kircher's attack was so successful and contributed so far to the discrediting of Kepler, that a half century later, Newton could be celebrated as the "discoverer" of celestial mechanics, who, allegedly through the falling of an apple, was the first to arrive at the idea of treating the physics of the heavens and of the Earth in the same way.
19. Quoted from the biography *Johannes Kepler,* by Max Caspar, 1948, p. 320.
20. Kepler thereby left it completely open, that there could be different inner harmonies.
21. Quoted from Rudolf Virchow, *loc. cit.,* p. 21.
22. Lyndon LaRouche, *So Streng Wie Frei,* Böttiger Verlag, Wiesbaden, pp. 51ff.
23. A penetrating presentation of the work of Fresnel is "Optical Theory in the 19th Century, and the Truth about Michelson-Morley-Miller," by Laurence Hecht, *21st Century,* Spring 1998, p. 35.

Anti-Gravity: Myth or Reality

by Rémi Saumont

Is anti-gravity possible? Has it been demonstrated? Is gravity an electromagnetic force? The author, a French physicist and former research director of a major scientific institution, brings light and heat to this much debated topic.



Escaping the attraction of the Earth is a very old aspiration. In literature and inscriptions on ancient monuments, the story is told of winged creatures, or men that can fly. Mercury, the messenger of the Greek gods, was represented with wings on his feet, and even back in the time of ancient Egypt we find images of winged figures, such as those preserved in bas-relief in the Department of Egyptian Antiquities at the Louvre in Paris.

Closer to the present, especially since the beginning of the 17th Century, many stories (more or less mythical) and proposals have appeared, some of which prefigured the real "flying machines" that came later. Often the question was not just voyages in the air, but up into space, as, for example, in the novel by the Englishman, Godwin, *The Man in the Moon,* which appears to have inspired Savinien de Cyrano, known as Bergerac (1619-1655), in his stories "Voyage to the Moon" and "The Comic History of the States and Empires of the Sun." Remarkably, Cyrano speaks explicitly of the propulsion of one of these machines by rockets.

A century later, at Marseilles in 1806, the artisan Claude Ruggieri accomplished the practical application of this means of propulsion, on a scale far surpassing that of the fireworks known since the time of ancient China. By

means of a necklace of rockets, Ruggieri succeeded in lifting a live sheep more than 600 feet into the air, bringing it to a soft landing with a parachute.

However, as such accomplishments did no more than utilize Archimedes' buoyancy principle for the medium of air (in the case of the baloonists), or the principle of action and reaction (in the case of rockets), the fight against weight had only succeeded in counterbalancing the effects, without modifying them a bit. The principle of the airplane—a craft "heavier than air"—so widely in use today, was not an exception to the general rule. Thus, even today, we do not know how to fight against weight, except by opposing to it forces of another nature, the which cannot be done without posing some delicate problems of a dimensional type, as we will see below.

What differentiates the mode of propulsion of a rocket from all the others (both the lighter- and heavier-than-air vehicles) is that it works in a vacuum—even better than in the air. So, almost 50 years ago, the birth and development of astronautics took place, which, even at the end of the first 40 years of this century, seemed more like science fiction than reality.

As experience teaches, the dreams of pioneers are often realized much more rapidly than their contemporaries could have imagined. Our present time abounds in facts of this kind. This was the case for radar, antibiotics, nuclear power plants, the transistor, television, intercontinental missiles, the high-speed train (TGV), organ transplants, computers, the genome, and so on.

On cursory examination, there seems no limit to the speed of the technological revolution, which tends to take on an exponential character.

Yet, there remains an area, in addition to that of controlled nuclear fusion, in which man's ingenuity seems to have been dancing around for the last 30 years: the realm of interplanetary space travel—which, at the beginning, had taken off with fireworks (both figuratively and literally). In the 1960s, we moved quickly from the rudimentary Sputnik to a trip to the Moon, and even, by use of robotics, to the confines of the solar system. But, today, we still use the same techniques, which are so costly that it is not even financially possible to repeat the accomplishments of the past, and, for example, to colonize the Moon.

In this domain, an apparently invincible enemy blocks progress: weight—the tangible manifestation of a phenomenon studied since antiquity and defined and codified under a general form, three centuries ago, by Newton as "gravitation."

This reality did not escape the author who was made famous at the beginning of the 20th century by his bold anticipation of "fiction" that would soon become "fact," H.G. Wells (1866-1946). In his novel *The First Men in the Moon,* Wells does not use a rocket motor, or a giant cannon like Jules Verne's (see my article in the January-February 2000 issue of the French-language *Fusion*), but a much more subtle procedure, perhaps inspired by the theory of Lesage.[7] Movable screens, which intercept the force of gravity in a given direction, are used, made of a new substance called "Cavorite"—after its inventor, Cavor, the hero of the book.[5]

It seems, as intuited by Wells, that if, some day, man gets to the point where he can leave his minuscule solar system, or at least get to explore it himself, that he will not do so by using rockets, which have already demonstrated their limitations, but by mastering the phenomenon of gravitational force.

Let us be clear. This incontrovertible truth has not escaped some of our contemporary researchers, for whom the concept of "anti-gravity"—it would be more correct to say "de-gravitation"—cannot be restricted simply to the act of checkmating the force of gravity, by opposing to it a force of another kind (and of an intrinsically different dimension), such as electromagnetic forces. Rather, it becomes a question of defining the eventual procedures, which will permit us to directly modify the intensity of gravitational action, even if our present level of theoretical understanding is admittedly still rudimentary.

Gravity

The idea of a universal force of gravity, governing the movement of the heavenly bodies, was defined, as we know, by Newton (1642-1727), who termed it "universal attraction,"[2] in order to distinguish it from "weight." Weight is only a local condition of the force of gravity, resulting from the force of the Earth's attraction, but excludes those forces depending on the body in free fall, which are considered negligible. We will see below how restrictive this concept was, and how heavy with consequence.

Weight

The phenomenon of weight that causes heavy objects to fall to the surface of the Earth, has been known from the dawn of human intelligence, and it seems that the study of its laws goes back to antiquity. In fact, a study of falling bodies was probably carried out by Epicurus (341-270 B.C.), as indicated by the account of Lucretius (99-55 B.C.) in his book *De Natura Rerum* (See box, page 29), which makes it seem somewhat unjust to attribute this accomplishment to Galileo alone (1654-1642), with his celebrated experiments from the leaning tower of Pisa.[1]

A test body, attracted in a vacuum by a heavenly body, is said to be in free fall. The speed it attains, under the effect of acceleration of the weight $V = g \cdot T$ (where g is the acceleration, and T the time elapsed since the fall began), does not depend on the volume, or the mass, both of which are considered negligible with respect to that of the star. It is, hence, subject to an acceleration multiplied by a constant, whose value depends only on the force of attraction exerted by this star, and is a function of the star's mass. Because of the approximation thus introduced, this acceleration does not create any sort of mechanical stress inside the body in question, such as is usually created by the force of acceleration on a moving body; therefore, an observer linked to this moving object, but deprived of any external proof of his acceleration, will be unaware of it, while an accelerometer attached to the moving object will register zero. Thus, because of this use of a first approximation, the gravitational field is considered identical with the inertial field, and the intrinsic dimension of the force of weight has been taken as

the same as that of inertial force. Such an identity was justified by the experiments of Galileo, Newton, Eotvos, and Zeeman, for example.

The formula for the inertial force has been known since Newton, that is to say the fundamental law of dynamics:

$$F = Mg = MLT^{-2},$$

where the inertial force, *F,* exerted on a body in accelerated rectilinear motion, is equal to the product of its mass *M,* and acceleration *g,* that is to say, dimensionally, to a product of a Mass multiplied by a Length, divided by the square of Time.

In analyzing the process of free fall, the motive force of weight is thus combined, dimensionally, with the force of inertia, which implies the assumption, by local approximation, that the field of the weight is a uniform field.

Dimensionally speaking, acceleration is considered as a constant, equal to 1, so that the unit of force of weight becomes just the unit of mass. That is why, in making this approximation, physics may express the force of weight in kilograms, and remain within the limits of error of the best experimental determinations cited above, and one can assume that the inertial masses of all objects are (within the range of this approximation) proportional to their gravitational masses (weight).

All of classical (pre-relativistic) physics was constructed starting with these elementary givens of fundamental mechanics.

In considering a falling body, one supposes, therefore, that the motive force is applied homogeneously to all the elements, no matter how small, of the body thus accelerated, the which assumes that none of these elements acts as a screen relative to the others. The force of weight would thus act according to the volume of three-dimensional space, and, in such a way that the matter of the body subject to the action of the field, is not modified in structure by it. This to say, that it is perfectly "transparent" to the phenomenon, as Newton already noted in his *Principia.*[2]

Considered more rigorously, this assertion reflects the fact that the equations of gravitation are non-linear, because, in the case of weight, the structure of the field depends only on the structure of its source.[13] In the case of weight on Earth, the volume of the planet is sufficiently great, that at the very small local scale, the field lines are assumed to be emanating from a plane surface; they are thus parallel and remain so with the falling body.

This characteristic of matter is peculiar to the field of weight, the weight being considered as a motive field of the body's motion.

Electrodynamics and Its Possible Gravitational Implication

But things are quite different when it comes to an electric or a magnetic field. Indeed, the equations for an electromagnetic field are linear,[13] and the matter within bodies accelerated by this type of field, changes the distribution of the field lines surrounding the body.

The result is that, matter, because of the existence within it of electrical repulsion and attraction, plays the role of a screen. Experience has shown that in such a case, which is true for the motion brought about by all the motors our technology knows how to build (steam engines, internal combustion engines, electric motors, rockets, and so on), the propulsive force is always exerted, not on a volume, as is the case for weight, but on a cross-section. Newton had already noted this fact when he spoke of "mechanical causes" to distinguish them from "gravitational causes" (*Principia,* Book 3, General Scholia, pp. 178-80 of Volume II).

Experience confirms the truth of this analysis, which was taken up again by Sir Arthur Eddington in his book *Space, Time and Gravitation.*[9] This is the typical case, for example, of a pilot subjected to a significant acceleration, such as when his plane is being catapulted from an aircraft carrier. The propulsive force transmitted by the back of his seat is applied directly only to the molecules of his back. His body thus becomes the recipient of the mechanical stresses, which will lead to his destruction if the acceleration is too high. A deceleration produces the same kind of mechanical stresses inside the moving body, as if it had been subjected to a shock. Then again, stresses created by forces of electrical resistance, are brought into play, whose direct effect takes place only on a cross-section, as opposed to the inertial forces which act on the whole volume.

These kinds of experimental facts would lead us to assign an intrinsically different dimensionality to electromagnetic forces, from that attributed to the forces of weight or inertia. Everything else being equal, the electromagnetic forces grow as the square of the linear dimension of the system under consideration, while the force of weight grows, under the same conditions, as the cube of this dimension.

I have shown elsewhere[26] (Chapter IV, p. 63) that the density must also be taken into account in formulating the intrinsic dimension of these electromagnetic forces, such that their dimensional equation is: $F_e = DL^2$, because the dimensional equation of the force of weight or inertia is: $F_i = DL^3$.

The dimensional system which derives from that, requiring only two primary units, is the only one which responds to the assumptions of Special Relativity (see table, page 54), as I indicated in my book *Analyse dimensionnelle et similitudes en physique fondamentale.* (See also my articles on the general-

Lucretius on Falling Bodies

"For whenever bodies fall through water and thin air, they must quicken their descents in proportion to their weights, because the body of water and subtle nature of air cannot retard everything in equal degree, but more readily give way overpowered by the heavier; on the other hand empty void cannot offer resistance to anything in any direction at any time, but must, as its nature craves, continually give way; and for this reason all things must be moved and borne along with equal velocities though of unequal weights through the unresisting void."

—*Lucretius,* De Natura Rerum, *Book II, Summary of an assertion of Epicurus in a letter to Herodotus*

ization of physics which appeared in the French-language Fusion, Nos. 59, 60, 61).

For reasons of simplification, pre-relativistic physics found it convenient, when confronted with the occurrence of the dimension of inertial force, MLT^{-2}, to attribute the same dimensional formula to all the forces, no matter what their origin. In such a case, this is an approximate equivalence of units, which could be used only by introducing into the equations—to meet the demands of homogeneity—the famous dimensional constants which have been so much abused.

In working in this way, all the questions relating to the real dimensional heterogeneity of different types of forces, were obscured. That is why, for example, no one can explain (and most physicists don't care) why pondero-motive actions of electromagnetic origin, act only on cross-sections. Above all, it is not even known if these cross-sections are in principle bi-dimensional, might have a "thickness" and, if they do, it might lead to assigning them a fractional geometric dimension (hence fractal) greater than 2.

In fact, such a problem is considered marginal and does not interest anyone except the so-called "fools" who are working on anti-gravity. In fact, if it had some thickness, that would mean that action of an electromagnetic nature might contain the germ of an intervention of a gravitational type, the which, as we shall see, might correspond to observable reality.

Asking oneself these kinds of questions, shows how interesting a greater geometrization of physics might prove to be, as extolled by, among others, René Thom (Medaille Field 1958).

One can thus see what a stifling role the adoption into physics of a dimensional system with three primary units, has been able to play, and still plays. The most caricature-like example of this is Coulomb's law (1736-1806), by which one is allowed to think only of point charges—that is to say, an infinite electrical density, which is stupid. That is the kind of problem one encounters only too often in physics, which means that it might be necessary to carry out, what can be modestly called, a "re-normalization."

Universal Gravitation

Newton's law of universal attraction, which accounts for gravitational interaction, is the homologue of Coulomb's law in matters concerning general gravitation. Contrary to Coulomb's law, the only thing brought into play here is attractions between "charges," whose masses are so well defined on the dimensional level, that the determination of the intrinsic dimension of the force of general gravitation is immediate:

$$F_g = DL^3 \cdot DL^3 \cdot L^{-2} = D^2L^4 .$$

Thus it is evident that the dimensional expression of this force is different from that of the force of inertia. It follows that the principle of equivalence between inertia and gravitation, on whose basis general relativity was developed, can have only an approximate local character, just as weight does, but

PRINCIPAL DIMENSIONAL SYSTEMS AND THEIR RELATIONSHIPS

		Traditional systems	Systems with a reduced base			
		CGS, MKS, etc	Electromagnetism and inertia	Inertia and weight	Inertia and gravitation	Electromagnetism, inertia, gravitation
			SPECIAL RELATIVITY	FROUDE RELATIONS	ASTRONOMICAL SYSTEM	GENERAL RELATIVITY
Dimensional base / Scales of . . .		Length Mass Time	Length (Mass-volume)	Length (Mass-volume)	Length (Mass-volume)	Length
Length	λ	λ	λ	λ	λ	λ
Force	φ	$\mu\lambda\tau^{-2}$	$\delta\lambda^2$	$\delta\lambda^3$	$\delta^2\lambda^4$	1
Time	τ	τ	λ	$\lambda^{1/2}$	$\delta^{1/2}$	λ
Mass	μ	μ	$\delta\lambda^3$	$\delta\lambda^3$	$\delta\lambda^3$	λ
Mass-volume	δ	$\mu\lambda^{-3}$	δ	δ	δ	λ^{-2}
Velocity	β	$\lambda\tau^{-1}$	1	$\lambda^{1/2}$	$\delta^{1/2}\lambda$	1
Acceleration	γ	$\lambda\tau^{-2}$	λ^{-1}	1	$\delta\lambda$	λ^{-1}
Impulse	χ	$\mu\lambda\tau^{-1}$	$\delta\lambda^3$	$\delta\lambda^{7/2}$	$\delta^{3/2}\lambda^4$	λ
Energy	ε	$\mu\lambda\tau^{-2}$	$\delta\lambda^3$	$\delta\lambda^4$	$\delta^2\lambda^5$	λ

It is the necessity of taking into account the stresses that arise within a body being accelerated by non-gravitational means, which leads to assigning the intrinsic dimension, DL^2, to motive or resisting (electromagnetic) forces. (See references 26 and 38). By considering the equation $F_e = DL^2$ as a primary dimensional relation, of the same kind as the equation for inertia $F_i = MLT^{-2}$, we are led to the definition of a dimensional base of only two primary units, whose equations of similitude, independently of all referential conditions, correspond in every point to the conditions of Special Relativity. Continuing in this way, and considering the intrinsic dimensional relationship of Newtonian attraction as $F_g = D^2L^4$, one ends up with a system whose base is reduced to the single unit of a length, which is that of General Relativity.

on a larger scale. It is this lack of dimensional homogeneity between the force of general gravitation (in L^4) and the force of inertia (in L^3), which brings with it the necessity of assuming the existence of a distortion in the fabric of Euclidean space, on a cosmological scale.

General relativity is a descriptive interpretation, which has but little impact on the terrestrial scale, and teaches nothing about the nature of gravitational force, because it ends up denying its existence by relegating it to a deformation of space.

Curiously, however, by integrating the relationship of Newton's attraction, into the group of fundamental relationships between inertia and electromagnetism, we come to a system of reduced dimension, to a single unit—length—which meets the criteria for general relativity (see Table). Thus, it was not that Newton's law of attraction was invalid. but rather that the use of dimensional constants have proven incapable of correcting the intrinsic dimensional heterogeneity (relative to the Euclidean) of fundamental mechanical phenomena.

That points to the fact that in physics, we have not taken geometry sufficiently into account. Physics is a discipline in which the validity of dimensional equivalencies depends upon the spatial structure of the relevant magnitudes—so much so, that in this domain one cannot claim equivalence, without reference to the overall conditions that determine the assignment of units.

Since Newton, many attempts have been made to get to the bottom of the nature of gravitation. One of the oldest of these theories was Lesage's (Figure 1), which Poincaré criticized as not corresponding to reality, in his book *Science et Methode*. Marcel Doliguez took up the idea again in 1965, attributing to "gravitons" (tiny, subtle particles, which he assumed would be responsible for the effect of gravitation) velocities much greater than the speed of light, and a mean free path on the order of cosmological distances. It is possible that this was inspired by the *corpora prima* of Lucretius (him again), which, according to the Latin author, displaced themselves in a vacuum "in going much faster than light rays" ("multo citius quam lumina solis," *De Natura Rerum*, II, p. 162).

Just as in relativity, the theory of Doliguez furnishes an explanation and a method for calculating the advance of the perihelion, but unlike relativity, no one tried to take it any further.

These corpuscular theories of gravitation have had a number of more or less talented defenders. One of the most impassioned, Marcel Pagès, holder of numerous patents, had to defray the cost of this effort for about 50 years or so, beginning in the 1920s. His experimental work was of the sort that "bears on everything," concerned primarily with what was termed, perhaps wrongly, "electro-gravitation." At the end of the 19th and beginning of the 20th Century, the latter was the object of the attention of a number of famous engineers and physicists, including Ducretet, Helmholtz, Ruhmkorff, and Lorentz, which resulted in experiments on "de-gravitation" (or, supposedly so) of discs turning under the effect of a field produced by electrostatic machines, and condensers charged to very high voltages.

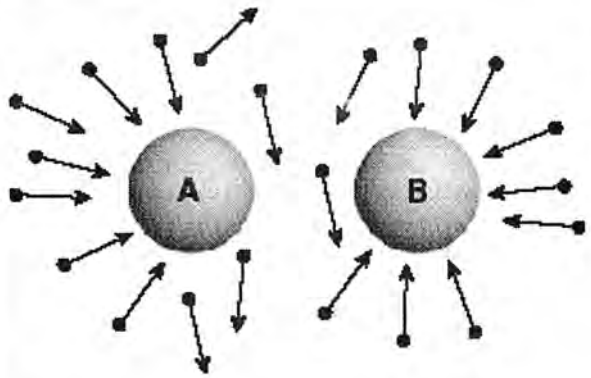


Figure 1
LESAGE'S THEORY OF GRAVITATIONAL SCREENING
Lesage's gravitational theory supposes that interplanetary space is filled with very subtle particles, circulating at great velocity. An isolated material body, A, is not affected by the impacts of these particles, because they come equally from all directions. But, if another body, B, is in the presence of the first, each of the bodies screens the other one from the effects of the particles, so that the two bodies are pushed together, in a relative motion that takes the form of an attraction. Poincaré criticized this conception in his book Science and Method, *showing that it does not correspond to reality. Marcel Doliguez re-adopted the theory, modifying it to make it more plausible—but not convincingly.*

In his experimental eclecticism, Pagès, in collaboration with Drouet, also made use of gyroscopic techniques, supposed to permit the construction of apparatus that would eliminate the effect of weight. He describes such an apparatus in his book[21] (p. 23), which has an odd resemblance to one described in a recent English patent application (See box, p. 32).

In his theory, he assumes space to be an energetic atmosphere, within which are to be found material bodies in a state of "Archimedian" flotation (to use his terminology). It is astounding that such a crude theory was able get any response at all, no less to become the subject of articles, some of them praiseworthy, in aeronautical, astronautical, and popular science magazines. As noted by Jean-Pierre Petit[30], the so-called anti-gravitation of the spinning discs, might have been nothing more than an aerodynamic effect caused by greater or lesser scoring of the upper face of the discs, leading to a lower air pressure at this surface.

Another genre of anti-gravity theories rely on a purely mechanical interpretation, inspired by the astonishing properties of gyroscopes, or on a possible variation on Newton's Third Law, that is, the equality of action and reaction (see in this regard, the exhaustive article by Patrick Cornille[42]).

Almost since the beginning of Mechanics, it has been known that a body cannot, by itself, change its own state of kinetic translation [velocity—ed.], because of Galileo's principle of the conservation of Motion.[1] More explicitly, the

center of mass of an isolated system cannot be put into motion by internal forces. (A rocket cannot be considered as an isolated system, because it gives up elements of weight to the environment through which it is passing.) Were such an action possible, that would lead to the admission of the possibility of perpetual motion. However, in this regard, it is interesting to compare translational and rotational motion, the latter, by definition, also kinetic in character (Figures 2 and 3).

It has been established that, even though an isolated system cannot, on its own (that is to say, without any point of support), change the translational motion of its center of mass, it can, considered as an extended system, change its orientation in space, without any problem—so long as that does not change the position of the center of mass. This is accomplished precisely by using Newton's Third Law, as is shown in Figures 2 and 3.

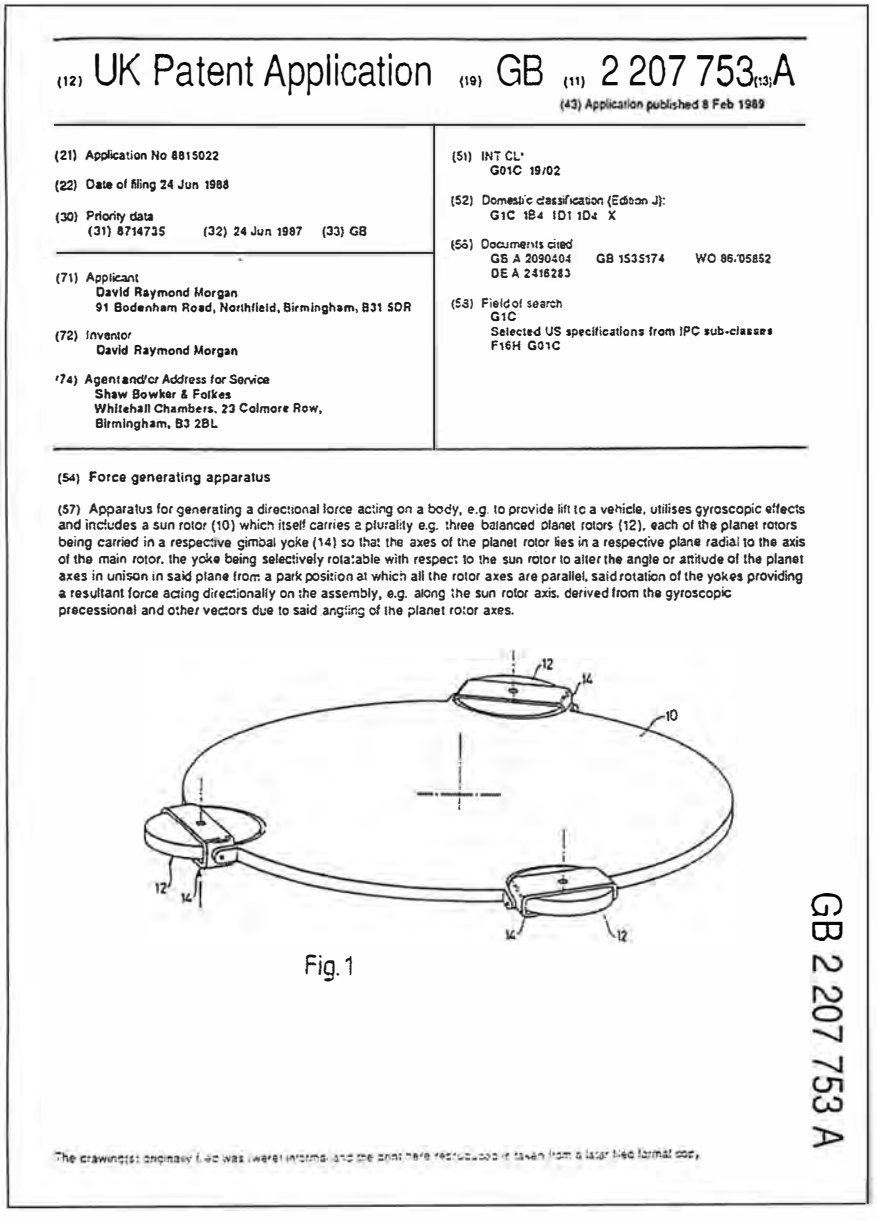
Here we find an example of the absolute nature of rotation, which has posed so many problems to physicists, because this change in orientation can be defined directly with respect to the so-called fixed stars, and thus depends strictly on Mach's Principle, which is presently assumed to be the basis of inertial phenomena.

A system which is isolated, from the electrodynamic standpoint, but subject to a gravitational field, hence would not have any possibility of maneuvering with respect to the field that is carrying it along in translational motion, any more than it could with respect to the inertial field.

Everything here points to the necessity of distinguishing between inertia and weight, in spite of the principle of equivalence. The novelist Jules Verne provides us an illustrative example in his novel *Hector Servadac*.[4] Captain Servadac finds himself pulled towards a planetoid that was ripped away from the Earth by the shock of a comet. Because of its small size, weight at the surface is only one-sixth of that on Earth, a fact which leads the author to explain that this does not in any way change the way the Captain's watch keeps time: Regulated by its spring-driven balance-wheel, the watch depends only upon the inertial moment of the balance-wheel. The watch movement is thus not changed in any way by the change in gravity. That would not be the case for a timepiece driven by the periodic oscillation of a pendulum, whose operation is dependent on its weight.

Another kind of question also comes to mind in the case of the rotating system cited above (Figure 2). Would not the rotation of the subject, so conceived, correspond to an increase in the internal energy of the system, as in the case of a flywheel which stores up the energy imparted to it in the form of kinetic energy of rotation?

Evidently, nothing of the sort occurs, because by virtue of the Third Law, the rotational motion in the example cited must faithfully follow the order of the movement of the arms, but in reverse direction. This fact, however, does not avoid some other nasty questions: Between the time of the action and the time of the reaction, there would not be an instantaneous "transmission mechanism" Some time delay (admittedly very small) would hence be necessary, between the movement of the arm and the response of the rest of the system, considered, for example, relative to the center of mass. This is a delicate question that certain researchers have tried to explore—among them Norman Dean, in his 1959 patent dealing with the possi-



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GB A 2090404 GB 1535174 WO 86/05852
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(58) Field of search
G1C
Selected US specifications from IPC sub-classes
F16H G01C

(54) Force generating apparatus

(57) Apparatus for generating a directional force acting on a body, e.g. to provide lift to a vehicle, utilises gyroscopic effects and includes a sun rotor (10) which itself carries a plurality e.g. three balanced planet rotors (12), each of the planet rotors being carried in a respective gimbal yoke (14) so that the axes of the planet rotor lies in a respective plane radial to the axis of the main rotor, the yoke being selectively rotatable with respect to the sun rotor to alter the angle or attitude of the planet axes in unison in said plane from a park position at which all the rotor axes are parallel, said rotation of the yokes providing a resultant force acting directionally on the assembly, e.g. along the sun rotor axis, derived from the gyroscopic precessional and other vectors due to said angling of the planet rotor axes.

Fig. 1

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The drawing(s) originally filed were informal and the print here reproduced is taken from a later filed formal copy.

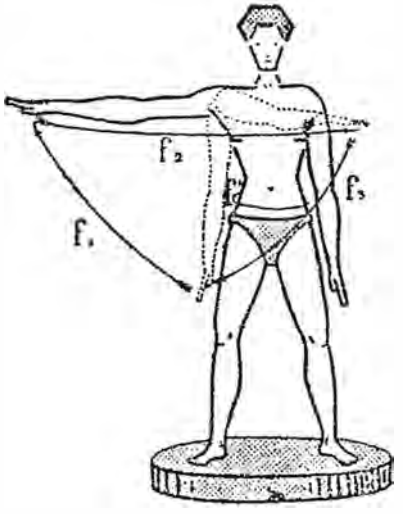


Figure 2
ROTATION IS POSSIBLE WITHOUT LOSS OF MASS

A moving object in a vacuum cannot acquire a velocity of translation without a loss of mass (propulsion by reaction). However, as the figure shows, it can change its orientation in space, without losing mass, by rotating around its own center of mass. The subject is standing on a disc which can rotate around a vertical axis. By motion f_1, he lifts his right hand in a vertical plane, perpendicular to the plane of symmetry of his body, which does not produce any rotation of the system. Then, by motion f_2, he sweeps his arm horizontally and leads it forward perpendicular to this plane: the disc rotates, by reaction, in the opposite direction. Finally, by motion f_3, the subject allows his arm to fall, returning to the original position, which causes no new change in rotational movement.

It would suffice for him to keep repeating the operation, in order to keep turning, as long as his arm motion continued. Certainly, if the subject found himself in free fall, without any support, the movement of rotation would be more complex, but mechanics shows, that even in this case, the subject could orient himself at will in space, as the cat does in Figure 3.

bility of transforming rotational motion into translation.[14] His apparatus does not seem to have had any useful application so far.

The same fate was reserved for the numerous patents that brought into play gyroscopic systems, such as Pagès', or the patent illustrated in the box on page 32, and it seems that whatever these effects might be, no one has been able to put them to any use. The de-gravitational effect of a gyroscope, described by Hayasaka and Takeuchi[28], has not been able to be reproduced, and researchers in Sèvres, France, have had to doubt its very existence, concluding that it was a result of experimental error. In this field, at times one finds oneself on the thin line between the real and the imaginary. This was perhaps the case for the Russian researcher, Podkletnov, who built a "de-gravitation" apparatus, using a superconducting ring; nothing more was heard of it from the moment his memorandum was accepted in the *Journal of Physics D: Applied Physics,* and then precipitously retracted by the author.

A third aspect of the research on the eventual possibility of acting upon the state of gravitation, or inertia, of a body, or system, rests on more recent knowledge in the fields of particle physics and electromagnetism.

Above all, is the theoretical work of Olivier Costa de Beauregard on the inertial effect of spin dating to 1965-1967[12], and confirmed by the precise experiments of Charles Goillot.[17] Goillot demonstrates the possibility of obtaining a translatory motion, on the scale of particles, in contradiction with Galileo's principle of conservation of motion. For the moment, this very beautiful result has not led to any practical results in the macroscopic world.

Presently, as is always the case in the domain of particles, a problem arises concerning the masses of different particles which constitute matter. The equivalence of mass and energy in Relativity theory is something observed, rather than explained. One does not always know precisely what are the internal mechanisms of the gravitational phenomena which permit the attribution of a rest mass to various particles, as for example to the six quarks, including the leptons (a very small mass). The problem also arises with respect to the rest mass of the electron, the neutrino, and also the gauge bosons, whose range of mass is so broad that it goes from a mass of zero for

Figure 3
HOW A CAT ALWAYS LANDS ON ITS FEET

Like the motion illustrated in Figure 2, when a cat that has been hanging upside down, falls, it is able to turn itself over before touching the ground, so as to land on its feet. Marey filmed this process in order to show the kinds of movements the animal performs to effect this rotation.

a photon, to the order of 80 GeV for the W and Z bosons of the electro-weak force.

These gauge bosons are exchange particles which mediate interactions, and the reason for the variety of their mass is not well understood. This led Peter Higgs, at the beginning of the 1960s, to predict the existence of a hypothetical mechanism, bearing his name, which would depend upon a fundamental scalar field. This served to support *a posteriori,* the theory of electro-weak forces of Steven Weinberg and Abdus Salam, and would explain why the electromagnetic force has an infinite range (boson of zero mass), while that of the weak force is on the order of the size of a proton or a neutron (a boson of very great mass).

The Higgs field does not behave in the same way as the vector fields (such as the electromagnetic or gravitational fields), because it tends to cancel itself at high energies, and thus gives an increased mass to the W and Z bosons. In fact, it would be this field which would give the mass to different particles, including quarks, to the degree that these particles interact with it, as seemed to be confirmed by Gerard t'Hooft in 1971. The reason for the photon's failure to interact with the Higgs field, would be that the photon has no mass; and the same would be true, it goes without saying, for the hypothetical graviton, the exchange particle of gravitational interaction. Higgs' theory would be validated by the discovery of a superheavy boson, which is currently being searched for by the high-energy physicists.

This is obviously front-line research, quite interesting on the theoretical plane, because it fits in with the "standard model" theory. However, it must be said, that as far as we can tell at this time, it does not seem to be getting us any closer to the practical mastery,—that is to say on our macroscopic scale—of gravitational phenomena.

In any event, experiment has shown us that in all circumstances, and for all types of phenomena, we cannot take hold of the world around us, except through the mediation of electromagnetism, as Eddington understood very well. Eddington says:

> Modern physics shows that the momentum is communicated [from one body to another] by molecular bombardment. We can visualise the mechanism, and see the molecules carrying the motion in small parcels across the boundary into the body that is being acted on. . . . [T]he sensation of weight is not felt when we are free to respond to the force of gravitation; it is only felt when something interferes to prevent our falling. . . . It seems literally true to say that we never feel the force of the Earth's gravitation; what we do feel is the bombardment of the soles of our boots by the molecules of the ground, and the consequent impulses spreading upwards through the body.[9]

This is true not only for the perception of gravitational forces, but also for nuclear forces: It is not until they provoke the emission of radiation, that we can recognize their existence. The so-called nuclear motor of our submarines, for example, is nothing but a common steam turbine, which functions only because the forces inside the atomic nucleus of the "fuel" of the "nuclear furnace," provoke the emission of particles capable of heating the matter through which they pass.

However, in contrast to nuclear forces, where it seems that geometry does not play a big role, the geometric factor assumes an importance with respect to inertia, as we have seen, in electrodynamics, and doubtless also plays a fundamental role in gravitation.

In light of this, it would seem that our only hope for acting on gravitational phenomena, would rest on the existence of a certain degree of geometrical interdependence between gravitation, and electromagnetism, which is the only type of phenomenon we can directly control.

In fact, a number of observations suggest that matter is not as transparent to gravitation as Newton and his successors thought. We have one example in the perturbation of the oscillation of Maurice Allais's paraconical pendulum, which, it seemed to him, was caused by the Moon's acting as a gravitational screen during eclipses.[39–41] It is possible that this is a genuine manifestation of electro-gravitation, which gives us hope that we might find a way to control gravitational phenomena using electromagnetism.

Against such a hypothesis—which certainly does not have the approval of the authorities in physics—it is often argued that there is an enormous disparity in intensity between electromagnetic and gravitational forces; on the scale of particles, the ratio is on the order of 10^{40} (1 followed by 40 zeros). It is certainly not as high for us on the macroscopic scale, a fact which, above all—apart from the dimensional aspect—results from the existence, in electrodynamics, of electrical attraction and repulsion. It remains the case that our technology has no

B. Soldano on the Non-Equivalence of Inertial And Gravitational Mass

Benedetto Soldano is one of the principal researchers who has worked on the violation of the principle of equivalence (whether it be strong or weak) between gravitational and inertial mass. To do this, he used data from the geostationary satellite, Lageos, launched by NASA in 1981, to establish exactly measured cases of this violation. For those who wish to delve more deeply into this question, we recommend Soldano's latest work, Non-Equivalence: A Key to Unity, *(Oak Ridge, Tenn.: Greenridge Press, 1997) where he develops the idea that non-equivalence permits the unification of classical, continuum physics with quantum physics.*

There is also an earlier article putting forward the same argument, which appeared in the International Journal of Fusion Energy, *(Vol. 3, No. 3, July 1985), under the title "Gravitational Binding Mass Nonequivalence and the Foundations of Physics." These writings are very technical.*

—Emmanuel Grenier

problem building engines capable of developing hundreds of tons of force (such as rocket motors). By comparison, the force of gravitational attraction acting between two 1,000-kg bodies set 1-meter apart, is on the order of 6.7 dynes, or 0.007 grams (mass).

One might come to the conclusion, that obtaining and proving the existence of gravitational variations experimentally would be practically impossible, because such results would be masked by overpowering effects of an electromagnetic character; and that in any case, such variations, which cannot be explained by the three-dimensional physics we use, would be of negligible importance, preventing any practical application.

But this kind of reasoning forgets the role played by the enormity of the Earth's mass (with respect to that of a test body) in the phenomenon of weight. Indeed, one must begin reasoning, not from the standpoint of the attraction between two bodies of 1,000 kg each, but from the attraction which exists between a body of 1,000 kg and the Earth, whose mass is on the order of trillions and trillions of metric tons (5.98×10^{21}). In this case, the attraction is exactly 1,000 kilograms (mass)—that is, a value comparable to that at which an engine is rated. That is why the Earth exerts an attraction of several hundred tons on a rocket, and why the rocket needs an engine capable of developing a force greater than this, in order to take off.

Therefore, we should not lose sight of the fact that the formula for the attraction of weight, contrary to the classical formula which neglects the role of the test body, is, in reality, a mathematical product of two factors, one of which is immensely greater than the other. In the case of attraction between two comparable masses, a slight variation in the mass of one body, produces only a feeble variation in the attraction as a whole. While in the case of weight, a slight diminution in the gravitational state of the test body—a "de-gravitation"—will result, contrary to what one might expect, in a significant decrease in the force of attraction to which it is subjected, as our calculation suggests (see box, page 36). The result of this calculation, though elementary, is paradoxical, and never suspected before, because the role of the test body was ignored by the introduction of a falsely simplifying and inappropriate approximation.

Will it therefore be necessary to revise some of the basic concepts of our fathers' physics? For example, need we reconsider the assumption of the identity of mass, considered as defining the quantity of matter, with that of mass considered as a gravitational charge? To make a distinction between them, might permit us to arrive at a definition of what we might describe—to use a neologism—as "de-gravitation," and that, for the case where only the charge is diminished, while the inertial mass remains the same.

It thus seems that on Earth, contrary to what has been assumed up to now, we have extremely favorable conditions for the detection of occasional acts of de-gravitation, which could produce quite measurable variations in the resultant forces. Contrary to current opinion, we should thus consider the couple *Earth-test body* as a system hyper-sensitive to all variation, even slight, of the gravitational state of the test body.

This is what can give substance to the various and sometimes kookish hypotheses of the proponents of levitation, one of whose precursors was William Crookes, no less.[3]

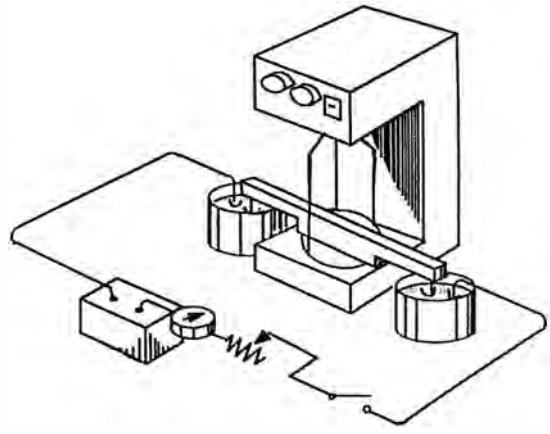


Figure 4
DEVICE FOR STUDYING THE MECHANICAL EFFECTS OF ELECTRIC CURRENTS

The circuit is powered by a capacitor, and includes an ammeter, a rheostat, and a switch. The enameled copper wire, covered with a stretched polystyrene insulation, is placed on the table, and its two ends dip into mercury beakers through which the electric current is led. The horizontal segment measures 13 cm; its diameter is 0.7 mm. Only the ends of the wire are bare; they are carefully polished and aligned planes.

The balance is a mechanico-optical type. The weight appears on a translucent dial situated above and to the right of the apparatus, which has a sensitivity better than a tenth of a milligram. The response time (damping) can be regulated.

As a prerequisite, it was determined that there is no deflection of this balance, when a stationary test wire, placed at the level of the table, is fed a current of 100 amperes, the which is not the case for modern electronic balances which cannot be used for this.

A Serious Study of a Curious Phenomenon

However, the indifference and mockery which anti-gravity researchers have had to suffer, has been unfounded. All it did was to dissuade many "serious" scientists from undertaking valuable research into a subject considered up till now as "too controversial."

In my case, to tell the truth, my interest in these phenomena began accidentally. My scientific interest was in dimensional analysis and relationships, and I applied this mainly to the study of phenomena at a scale above particle physics, and, particularly, to the dimensional analysis of electrodynamics. That is why a part of my activity was taken up with research aimed at establishing the existence of the Ampère longitudinal force, under various experimental conditions, and, most important, to measure its intensity, which had never been done before. I had no idea at the outset, that I would come to occupy myself with

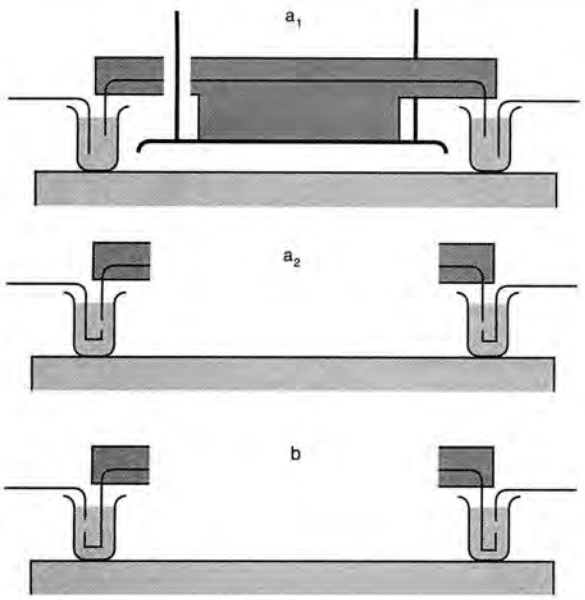
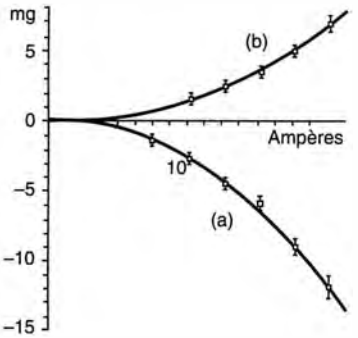


Figure 5
UNEVEN RELATIONSHIP OF WEIGHT LOSS TO WEIGHT GAIN

At left are the configurations first studied. Configurations (a) and (b) gave the same results. Below are the curves of weight loss (a) compared to weight gain (b). The X-axis shows current in amperes; the Y-axis shows the change in weight, expressed in milligrams.



anti-gravity in the sense defined above.

The equipment I used is described in Figure 4. It allowed me to confirm the existence of a force, originating within an (enameled) copper conductor carrying an electric current, and which manifests itself perpendicularly, at the carefully polished ends, where the wire dips into mercury baths that serve to make electrical contact. Measurement showed that the force varied with the current intensity, and, for a conductor on the order of 1 mm in diameter, attained values on the order of 5 milligrams of force for currents of a dozen amperes (Figure 5).

I will not describe here the precautions taken to avoid spurious effects (field effects on the balance, which was of the mechanical-optic type; heating; Biot-Savart-type phenomena of circuit dilation; the intervention of a Laplace force, Lenz force, and so on); nor the different kinds of experiments; they are described in my work listed in the bibliography. On the other hand, I will certainly insist on the existence of phenomenon of unexplained weight loss, which I at first considered as spurious, but which gradually became the most interesting result of the research: that is, the discovery of an astonishing process of loss of weight, produced by the passage of a current in the conductor, a process which has resisted all attempts to eliminate it.

First, I carried out two types of experiments described in Figure 5, which led, respectively, to a weight loss (configuration a_1, a_2), and an increase in weight (configuration b), which I at first attributed solely to the Ampère longitudinal force, exhibiting itself at the ends of the wire. Curiously, with a wire of a horizontal length of 13 cm, used at the beginning, the value of the observed deflection for the different intensities

A Very Weak De-gravitation Should Be Detectable

A simple calculation shows that it is not unrealistic to envision the possibility of measuring even a very weak de-gravitation, if it were possible to produce. Let two bodies be in gravitational interaction with their masses M_1 and M_2, the second having a mass incomparably greater than the first (the case of the Earth in phenomena of weight).

If by de-gravitation, the Mass of M_1 were diminished by a very small value m, this mass becomes $M_1 - m$.

If the distance which separates the two bodies is supposed not to vary (case of weight at the surface of the Earth), the force of attraction between the two bodies, which was,

$F' = M_1 \cdot M_2$ becomes: $F'' = (M_1 - m) \cdot M_2$.

The force is thus diminished by the amount:

$$F' - F'' = M_1 \cdot M_2 - (M_1 - m) \cdot M_2$$
$$= M_2 (M_1 - M_1 + m)$$
$$= M_2 \cdot m$$

A very small variation in the mass of the small body could thence be detected, because it would bring with it an important, and certainly measurable, variation in the force of attraction. Admittedly, this calculation presupposes that it might be possible to have a divergence between the mass considered as a gravitational charge, and the mass considered as a quantity of matter, the which would be the characteristic of a true de-gravitation.

A similar calculation shows, on the other hand, that a de-gravitation of the Earth, even of a much greater quantity than imagined here, would not have any measurable effect.

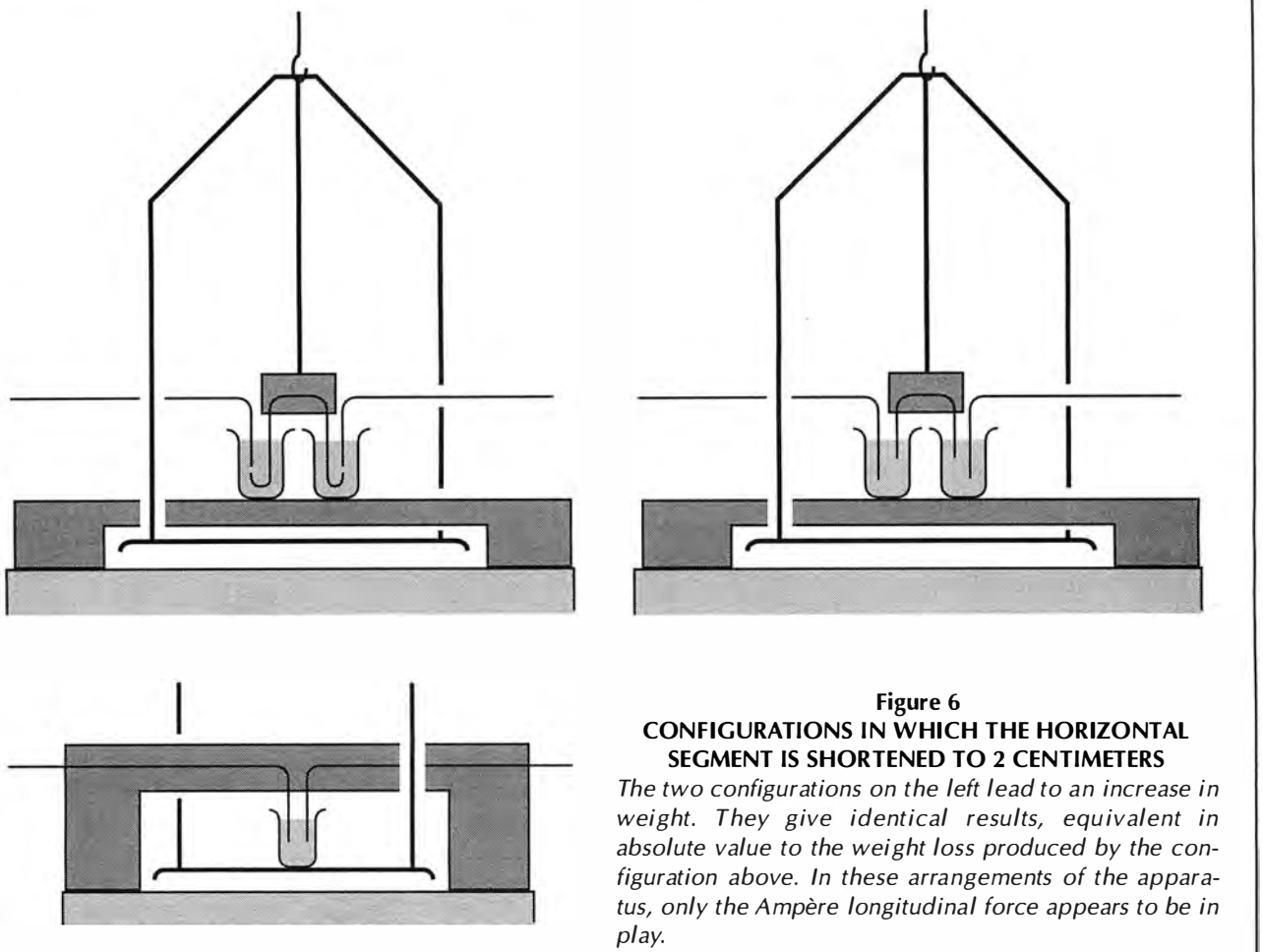


Figure 6
CONFIGURATIONS IN WHICH THE HORIZONTAL SEGMENT IS SHORTENED TO 2 CENTIMETERS
The two configurations on the left lead to an increase in weight. They give identical results, equivalent in absolute value to the weight loss produced by the configuration above. In these arrangements of the apparatus, only the Ampère longitudinal force appears to be in play.

tested always showed a net predominance in absolute value of weight loss over weight gain, as indicated by the curves in Figure 5. I thence carefully verified that it was not a Montgolfier type of effect, which could have been produced by a warming of the wire.[32]

It was only by shortening the horizontal part of this wire to 2 cm, that the weight loss diminished in absolute value to become almost identical to the weight gain (Figure 6). These are the values, obtained with the last apparatus, which are a manifestation of the Ampère longitudinal force, for there was no valid reason to suppose that this force could depend on the length of the conductor, as will be suggested below.

Continued investigation of the relative excess of weight loss has shown that, for the same electric intensity, it grew linearly with the length of the wire, or, more exactly, with the distance separating the points of entry and exit of the current in the wire; replacement of the straight wire with a twisted wire did not change anything. These results led me to eliminate any role for the Montgolfier effect, but, on the other hand, they suggested that it could be the result of the spurious effect of an electromagnetic field—the Earth's magnetic field, for example, or an electric field intervening in a fortuitous manner.

Even though calculation had shown that the intensity of the Earth's magnetic field was too weak to produce the observed effect, experiments were carried out, while systematically changing the direction of the current, the orientation of the apparatus, and the place of experimentation, none of which changed the results.

Certain experiments have even been carried out in such a way that the entrance or exit of the current was situated on an oblique line, close to the vertical, but without any change in the results.

In order to be sure that this effect did not depend on the longitudinal force (a force in principle analogous to the one produced by putting a series of little springs end to end), the ends of the enameled wire were bent back in such a way that their carefully polished terminal cross-sections would be perfectly perpendicular to each other, so that their interaction at this level would cancel out (Figure 7). There, again, the force of weight loss showed itself in the same way: It was practically null for a small distance between the points of entry and exit of the current; it grew linearly with the distance for a given intensity; and, for a given distance it grew, just like the Ampère force, as the square of the current intensity. For a wire 13 cm long, and a current of 15 amperes, it is 2.75 milligrams.

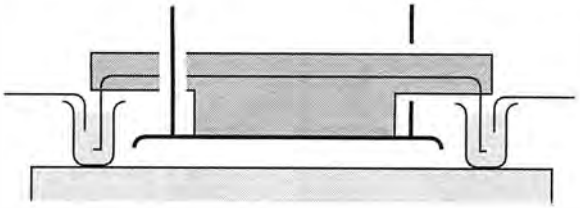


Figure 7
CONFIGURATION WHERE THE AMPERE LONGITUDINAL FORCE IS CANCELLED

In this configuration, the Ampère longitudinal force is cancelled, because the ends of the wires are oriented perpendicular to each other. [A longitudinal force on the bent wire would tend to push the balance arm to the side, not up or down—ed.] But a weight loss still occurs. For a given current intensity, it is proportional to the distance separating the points of entry and exit of the current, while for a given distance, it is proportional to the square of the current intensity.

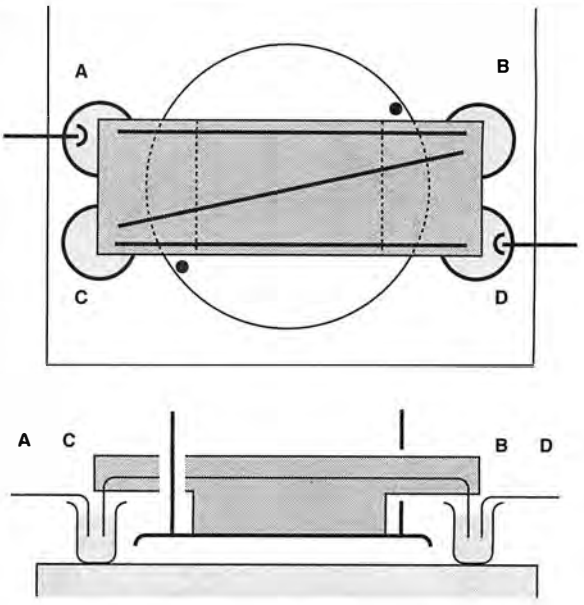


Figure 8
ELIMINATING SPURIOUS EFFECTS

The values of the weight-loss obtained with this arrangement are no greater than those obtained with the configuration in Figure 5(a) and (b). This experiment allows us to eliminate the possible spurious effect of surface tension at the wire-mercury interface. It also eliminates the Montgolfier effect as a cause of weight loss.

This is a curious phenomenon, which, to my knowledge, has never been observed, and deserves to be analyzed.

The wire is lightened, certainly, but in relation to what? As a function of what? In fact, it would seem that the wire cannot be considered as an isolated system. But, keeping in mind the precautions taken, its weight loss cannot be coming from an electromagnetic field (originating in the electrical power source, for example), nor is it coming from a point in the fixed base of the apparatus. Neither can it be the result of some aspect of the dynamic support, such as, for example, a change in the surface tension appearing at the interface of the wire with the mercury, because in the experiments on the Ampère force, the interposition within the circuit of two additional interfaces did not change the results in any way (Figure 8). The wire is thus free to move up and down like the solid support of the balance platform whose movement it causes, as noted after optical amplification on a graduated measuring scale.

Under these circumstances, can one apply the principle of the equality of action and reaction —Newton's Third Law, to the upward displacement of the wire? There is clearly action—the upward movement, but where is the reaction? If it is at the level of the counterweight of the balance, in this case, it could then be a gravitational effect, like that which acts on the weights placed on the platform of a Roberval balance near equilibrium.

It useful to pursue this line of experimentation, which is in line with various other experimental efforts alleged to have produced de-gravitation by application of electromagnetic processes.

A certain number of these experiments was done with flat condensers, which experienced a loss in weight when they were charged to very high voltages (200,000 V) by electrostatic machines (see in this regard the exhaustive discussion in Alexandre Szames's book[40]). Under such conditions, it is difficult to distinguish what part might be caused by de-gravitation, and what part must come from spurious, purely electrostatic effects.

One can say, however, that in the case of the "escape" current (and even more for the "breakdown" current) in the interior of the dielectric of an already charged condenser, just as as in my experiments, it involves elements of current occurring in a substance that can be considered as mechanically isolated from its source. Perhaps we should see in this fact how (in connection with the calculation in the box on page xx) a de-gravitation of the first medium, relative to the second one linked to the Earth, can be demonstrated.

Conclusion: Solving the Mystery

It seems we are beginning to solve the mystery which has surrounded the workings of gravitation up to now. Progress is, admittedly, very slow. We have not made much progress, as far as intimate comprehension of the process is concerned, and are still at the stage of hypothesis, both on the microphysical and the macroscopic scale.

Nevertheless, a certain number of new facts have come to light, such as the inertial effect of spin of Costa de Beauregard; the Higgs field, which, if it is confirmed, will unfortunately not lead to immediate practical applications; and, on a larger scale, the results suggesting that matter is not absolutely transparent to gravitational phenomena.

I have therefore shown in the present article, that the concept of *de-gravitation,*—more restrictive and precise than that of *antigravitation*—implies the necessity of assuming, for the notion of gravitational mass, a dichotomy analogous to that applied to electrically charged particles; that is to say, a distinction (for the "charge" of gravitation) between the gravitational and inertial mass.

One such conception lies in the connection of the case in question with the independence of inertia and gravitation. By Mach's Principle, the inertial force of a system is the same everywhere in the universe, whether on the Earth or the Moon, while clearly this is not the case for the gravitational force of the system.

The process of de-gravitation may thus be defined as that which specifically produces a temporary weakening of the gravitational charge of a system, while its inertial mass remains unchanged.

By virtue of the elementary calculation in the box on page 36, it turns out that, respecting weight, if a de-gravitation of the test body should take place, its mass (considered as a charge) will play an important and hitherto neglected role, such that the least de-gravitation will necessarily produce a significant weakening of the force acting between it and the Earth (that is to say, its weight), and it will thus be easy to detect this de-gravitation which is, for its part, most often transitory.

Taking into account the facts pointing to an interdependence in geometric character between gravity and electromagnetism, it thus seems that certain electric or magnetic influences will be able to bring about specific variations in the gravitational charge, regardless of the invariance of the inertial mass of the system under consideration.

That is what the experiments which I (among others) have conducted and presented in this article have demonstrated, experiments which clearly must be repeated and confirmed, to definitively establish their validity.

In spite of the poverty of our knowledge of the intimate workings of this phenomenon, may we not be, at the dawn of the 21st Century, about to arrive at the mastery of gravitation, and thus to realize one of the oldest dreams of humanity, that of leaving this Earth to conquer the stars?

Rémi Saumont is the former head of the biophysics laboratory at INSERM, France's main medical research Institute, in Paris. He has continued research work in physics, especially matters relating to the Ampère longitudinal force, as an emeritus director of the lab.

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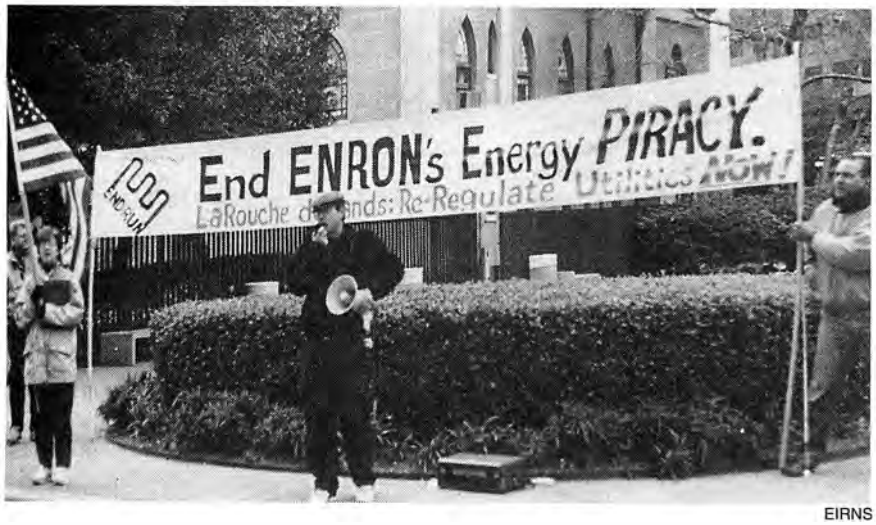


EIRNS

Enron Corporation, friend of the Bush family, has become a well-deserved target of angry citizens because of the plundering profits it has made, while energy prices soar beyond the ability of many residents to pay. This demonstration took place recently, across the street from Enron's corporate headquarters in Houston.

THE DEREGULATION FRAUD

It's Not 'Supply and Demand'

by Marsha Freeman

It has become increasingly clear that the sixth largest economy in the world, that of the state of California, is headed for a literal new Dark Age. Rolling blackouts on March 19 and 20, when electricity demand was one third *lower* than it is during the summer peak, was only a prelude to what the hot weather will bring.

Regardless of what you read every day, this crisis was not caused by a shortage of capacity, or power-hungry consumers, or environmental regulations, but by the "greatest train robbery" in American history.

Deregulation of the electricity utility industry was passed into law in 1996, by unanimous vote of the California State Legislature. The lawmakers were told by Enron, and other snake-oil salesmen, that such a radical policy would lower electricity costs in the state. Instead, the new law allowed a handful of wholesale electricity suppliers, most from out of the state, and most from George W. Bush's Texas, to take actions, including keeping generating capacity off line, in order to create the appearance of a shortage. This cover story was used to charge whatever ransom for power they could get away with, while they try to convince the gullible that demand has outstripped supply.

Since the spring of 2000, out-of-state power suppliers have increased the cost of electricity to the utilities more than 10-fold, from the level of $30 per megawatt-hour a year before. At one point last summer, spot market prices hit $1,400 per MW-hr. Approximately $13 billion in debt has been accumulated by the utilities, to feed triple-digit profits for companies that have been allowed to charge for power virtually whatever rate they want. And Californians, as well as New Yorkers and others, face the prospect of a summer 2001 season with shortages of power, and profiteer-prices for what is made available.

Not Supply or Demand

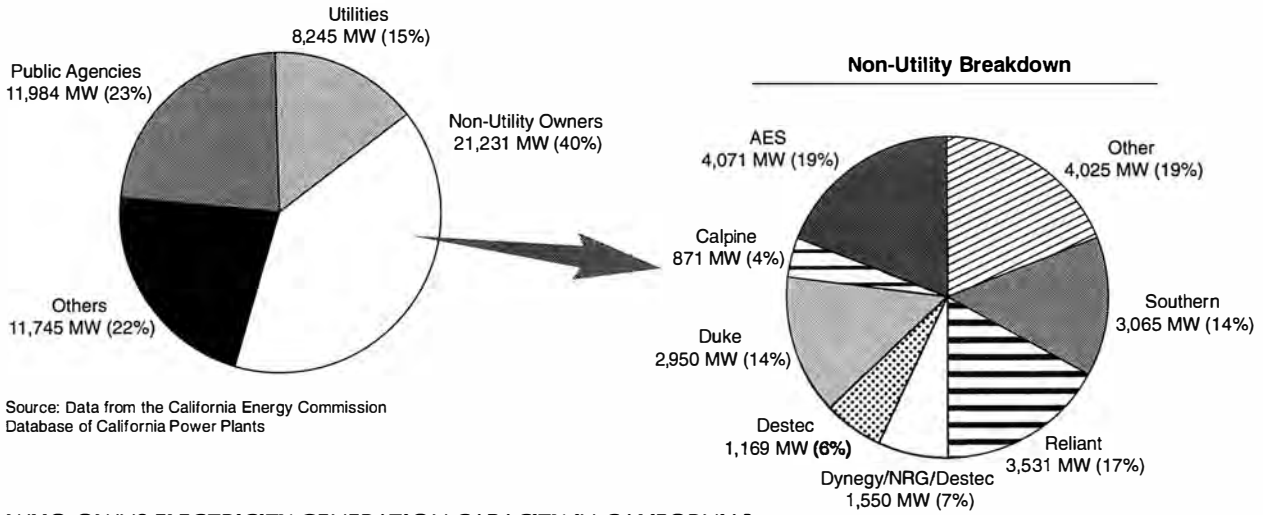
The problem is not supply or demand. It is deregulation.

On Aug. 2, 2000, the head of the Public Utilities Commission delivered a report to California Governor Gray Davis titled, "California's Electricity Options and Challenges." The report reveals that neither "supply and demand," nor unusual weather, nor increased costs to the producers, created the profiteering rates that wholesale suppliers were charging California's utilities.

Comparing June 29, 1999, to June 29, 2000, the report reveals that the peak load demands for electricity were about the same for both years, while the price charged by wholesalers was several-fold higher. The price of electricity on the day-ahead Power Exchange in California had zoomed to $522 in June 2000, compared to $49.65 the year before. The researchers found that last June, 3,000 fewer megawatts of power were available through the Exchange, concluding that that this suggests that "sellers may have been withholding power from this market in order to drive up prices. . . ." This is called "gaming" the market.

Although utility executives and regulators expected the crisis to ease after the summer, when demand customarily falls from a high of about 45,000 MW in the summer, to about 30,000 MW in the winter, the situation only worsened during November and December 2000. Suddenly, 12,000 MW of capacity in the state were taken off-line by suppliers, supposedly for unscheduled plant outages, creating another "shortage." The state regulatory authorities tried to investigate why there was a sudden rush of generation facilities undergoing repair, but in some cases these authorities were not even allowed to enter the power plants. There remain very strong suspicions that the plants were off-line again to "game" the market to drive up prices.

As the financial state of the utilities worsened, out-of-state wholesalers used that as an excuse to withhold supplies, stating they were afraid they would not be paid. According to an analysis done by the *San Francisco Chronicle,* using data from the state Independent System Operator (ISO), demand during December 2000 was 1.46 percent *less*



Source: Data from the California Energy Commission Database of California Power Plants

WHO OWNS ELECTRICITY-GENERATION CAPACITY IN CALIFORNIA?

Non-utility power brokers own 40 percent of California's electricity-generation capacity.

Data from the California Energy Commission Database of California Power Plants

than that of the previous year, but prices skyrocketed to $425 per MW-hr, compared to $53.47 the year before.

Market Gaming

The two days of rolling blackouts in mid-January were *not* caused by spikes in demand, but by the willful withholding of electricity by suppliers. The *Chronicle* investigation revealed that on those days, fewer power plants were down for repairs than earlier in the winter, so there was no shortage. The suppliers were simply refusing to sell.

For nearly a year, state officials have appealed to the Federal Energy Regulatory Commission (FERC), currently headed by free market ideologue and Trent Lott protégé Curtis Hebert, to investigate and punish instances of market gaming. Under intense political pressure, FERC's Hebert released a report on March 15 naming Williams Energy Marketing & Trading, based in Tulsa, and AES Southland of Virginia, as having taken power plants out of service in April and May of last year, for the sole purpose of driving up the price. Hebert stated that the companies should refund California $10.8 million. That's not even the tip of the iceberg.

Another factor leading to the rolling blackouts was the financial distress of the two utilities, Southern California Edison and Pacific Gas & Electric, which have been buying power from small producers, but not paying them for the electricity. About 3,000 additional megawatts were off line during the two days of blackouts in March, as non-utility producers, who generate relatively small amounts of power to sell to utilities, shut down their plants because they had not been paid since November. Creditors committees of these smaller producers have been formed, to try to force the two utilities into bankruptcy. Some face bankruptcy, themselves.

Industry spokesmen have claimed that the "shortage" of capacity in California is primarily the fault of consumers, who did not "conserve" enough (although the industry was, at the same time, not building new power plants). In testimony before Congress, figures as high as 13 percent for growth in demand have been cited. The *San Francisco Chronicle* analysis shows that the actual growth in demand for electricity in California was less than half that amount, and that the capacity was there to support it. Tom Kelly from the California Energy Commission supported the report's con-

CALIFORNIA ELECTRICITY SUPPLIERS' PROFITS FOR 2000
(in millions of U.S. dollars)

Company	1999	2000	Percent change
Calpine Corp.	$95	$323	240%
Dynegy	146	452	210
AES	228	657	188
Reliant	528	819	55
Enron	893	1,266	42
Duke Energy	1,507	1,776	18
Southern	1,276	1,313	3

Source: Company reports, analyzed by Public Citizen, Feb. 2001

WHO MAKES MEGA-PROFITS FROM CALIFORNIA'S ELECTRICITY PRICES?

The problems with electricity supply in California have little to do with supply and demand. It is the fact that 40 percent of its generation capacity is owned by unregulated out-of-state companies, that has allowed the state to be held hostage to market manipulators and speculation.

clusion, stating, "The claim that demand growth is rampant and that it was totally unexpected and due to the Internet economy, to Silicon Valley, or server farms, or people recharging cell phones—that's bogus. About as bogus as you can get."

Overcharges Documented

In November, the state's Independent System Operator (ISO), charged with operating the state's electric grid system, had filed a request with the Federal Energy Regulatory Commission (FERC), that it investigate the prices being charged by out-of-state suppliers. The ISO request stated these were not the "fair and reasonable" rates FERC is legally mandated to enforce. While FERC admitted the following month that there was some evidence of overcharging, it did absolutely nothing to force the suppliers to lower rates, and to refund money to the state.

In February 2001, the ISO filed formal charges with the Federal regulators, documenting $247 million of overcharges in December 2000, and $315 million in January 2001. On March 9, FERC admitted only to the possibility of $69 million in overcharges, asking the power suppliers either to justify their prices or to proceed with refunds, by March 23. The constraints imposed by FERC on what they would consider, and the pittance they are considering as possible overpayment, was attacked by Democratic FERC member William Massey, who voted against the order, and stated: "[T]his order is arbitrary, capricious, and unlawful. Eighty percent of the transactions have been excluded from refunds," even though they were over the supposed benchmark of $150 per MW-hr.

On March 22, California's Independent System Operator filed documents with FERC in Washington, alleging and documenting that between May 2000 and February 2001, 26 electricity suppliers charged in excess of *$6.2 billion* over the competitive market price for power.

Dr. Frank Wolak of the ISO's Market Surveillance Committee had informed his Governing Board on March 15, that based on an extrapolation of prices for the first two months of this year, with no effective mitigation measures, electricity costs in California could total $70 billion for 2001, compared to less than $6 billion in 1998, and $7.43 billion in 1999. It has been projected that the $10 to $12 billion bond sale that the state is planning for June may not be a 10-year stabilization plan, but instead may run out in September 2001!

Enron: All in the Family

The Bush Administration has pledged to do nothing to interfere with the embarrassing profits that Enron and the

Why U.S. Utilities Were Regulated

The anarchy and looting that is taking place now under the rubric of the free market is not unique; it is a repeat of history. To understand what brought an industry—which had been the great project of Thomas Edison and teams of scientists, inventors, and entrepreneurs—to bankruptcy and disgrace, it is useful to examine the history of one Samuel Insull, who, although made the scapegoat for the overall abuses in the industry, nonetheless exemplifies why electricity cannot be under the control of Wall Street interests.

Because building electric generating plants and transmission and distribution lines is highly capital intensive, financial interests such as J.P. Morgan established holding companies, with electric utilities as subsidiary companies, supposedly to raise the capital to build power plants and infrastructure. But when the payments from their electricity customers began to stream in, they were siphoned off into their financial empires, to develop financial pyramiding schemes. In 1892, Morgan pushed Thomas Edison out of control of the company Edison had established to spread this new technology, and Morgan created the General Electric Company.

A young man who had been in Edison's employ, Samuel Insull, became the president of Chicago Edison in 1892, and adopted Morgan's holding company structure, establishing Middle West Utilities in 1912. When Insull transferred his utility companies to the new parent holding company, he inflated the value of the stock 10-fold, allowing him to pyramid more stocks and bonds on those "assets." By 1916, Insull controlled 118 power systems operating in nine states.

By the 1920s, Insull and 15 other holding companies controlled 85 percent of the nation's electricity, through consolidations and mergers. Between 1922 and 1927, the holding companies swallowed up more than 300 small private companies *each year*. According to the 1986 book by Richard Rudolph and Scott Ridley, *Power Stuggle: The Hundred Year War Over Electricity*, the 1929 stock market crash was in no small part fueled by the speculation on huge volumes of electric utility stocks. They report that by the end of August that year, Insull's securities appreciated at " 'round the clock" rates of $7,000 a minute. Another utility holding company, AG&E, exchanged ownership of a block of stock 37 times in 30 days among its subsidiaries, to inflate the value several times over.

By 1932, with the depreciation of his highly inflated stock holding, Samuel Insull faced the largest bankruptcy in history. After the stock market crash, the holding companies took out bank loans to try to finance their money-losing operations. On April 16, when Insull's Middle West Utilities was placed into receivership by its Wall Street creditors, it controlled 239 operating companies, 24 holding companies, and 13 other subsidiaries.

By 1935, more than 90 electric and gas companies had fallen into receivership. Industry-wide, there were between 3 million and 5 million stockholders, who, as Franklin Roosevelt explained it, had gotten "fleeced."

Roosevelt's Decisive Actions

As early as 1932, when he was running for the Presidency, Franklin Delano Roosevelt recognized that electricity is not a luxury, but a necessity. He observed that a then-unregulated industry, controlled by Wall Street financiers, would never serve the needs of

other energy industry pirates are reaping from deregulation. That is hardly surprising because the President himself, and his energy and economic advisors, owe their allegiance not to the interests of the citizens who are paying for this economic policy fiasco, but to the robber barons who are raking in billions of dollars in profits.

Who are these new conglomerates who are holding the citizens of the state of California hostage, by overcharging them billions of dollars for what they claim is increasingly scarce power? One example of the corruption rampant in the new "free market" world of the deregulated energy industry is Houston-based Enron Corp. Starting out as a regional natural gas distribution company in the Midwest in the 1980s, Enron has become the largest marketer of electricity in the United States, with tentacles in more than two dozen other nations around the world.

Enron's increasing stranglehold over electricity and natural gas supplies, allowing it to dictate prices to industrial and residential customers, has not developed through its business acumen, but through its ties to the Bush family and its political connections. Enron moved into the wholesale marketing of electric power after passage in 1992 of the Energy Policy Act.

Enron was one of the most visible and vocal promoters of electricity deregulation, nationally and state-by-state. In Congressional testimony, Enron officials lied that consumer rates for power would fall 30 to 40 percent through the introduction of "competition." In actuality, when trying to justify a 1997 merger with Portland General Electric Company, Enron offered consumers an insignificant 0.3 percent rate reduction!

The Bush family's ties to Enron, and vice versa, did not leave the White House when George Bush Sr. was defeated for a second term. In 1992, Enron turned Bush Senior's electoral defeat into a "business opportunity," by bringing former Bush Secretary of State James Baker III, former Bush campaign chairman Robert Mosbacher, and former director of operations for the Joint Chiefs of Staff Lt. Gen. Thomas Kelly (ret.), into Enron. All three accompanied the former President on a trip to Kuwait in 1993, to help Enron secure contracts to rebuild energy plants that had been destroyed during President Bush's Gulf War.

President George W. Bush's "ties to the energy industry" do not stem from his failed attempt to run an oil compa-

Continued on page 48

Library of Congress

President Franklin D. Roosevelt introduced the first regulation of the utilities, recognizing that electricity is not a luxury but a necessity. When he ran for office in 1932, utility companies were in receivership and the electricity supply in chaos.

industry, agriculture, or citizens. Roosevelt used the power of the Federal government, in the spirit of the "general welfare" clause of the Constitution, to create an electricity industry that was the envy of the world.

In order to stop this looting and restore the industry to financial viability, with the intended purpose of providing universally available, reasonably priced, reliable electricity, President Roosevelt promulgated the Public Utility Holding Company Act (PUHCA), which is now under the threat of repeal. PUHCA instituted strict federal control of holding companies, forcing them to divest their utility interests, and conglomerates were broken down into single contiguous electricity systems.

Ownership of controlling shares by Wall Street firms was prohibited. *Power Struggle* authors Rudolph and Riley describe the intent of the bill as being "aimed at reforming Wall Street, as much as the power companies." The Act also gave the Federal Power Commission (since turned into the Federal Energy Regulatory Commission), control over both the interstate shipment of electricity, and the accounting procedures of the utilities.

Under President Roosevelt's leadership, the Rural Electrification Administration, the Tennessee Valley Authority (now under threat of being sold to "private" interests), and the power marketing administrations, which distribute power from federal dam projects (also under the threat of privatization) were created.

History Repeated

If this story does not sound familiar, it should. Today, under deregulation, the utility industry is again being consolidated through mergers and acquisitions, and rather than promoting "competition," a smaller and smaller number of holding companies is concentrating more and more of the nation's electricity supply in fewer and fewer hands. Most consumers today do not even recognize the name of the company that is selling them power.

As of March 3, PG&E, the parent company of the Pacific Gas & Electric utility, was making payments of $116 million in fourth-quarter dividends. The parent companies of both Pacific Gas and Southern California Edison were paying out dividends, defending "shareholder values," and trying to placate Wall Street, with total disregard for the fact that their utility subsidiaries were tottering on the brink of bankruptcy. Such is the priority of holding companies.

It is not too late to reverse the destruction that deregulation has brought upon the nation's vital infrastructure. As the history of regulation shows, re-regulation is going to require political will at the state and federal level, of the sort that President Franklin Roosevelt demonstrated in the last depression.

—Marsha Freeman

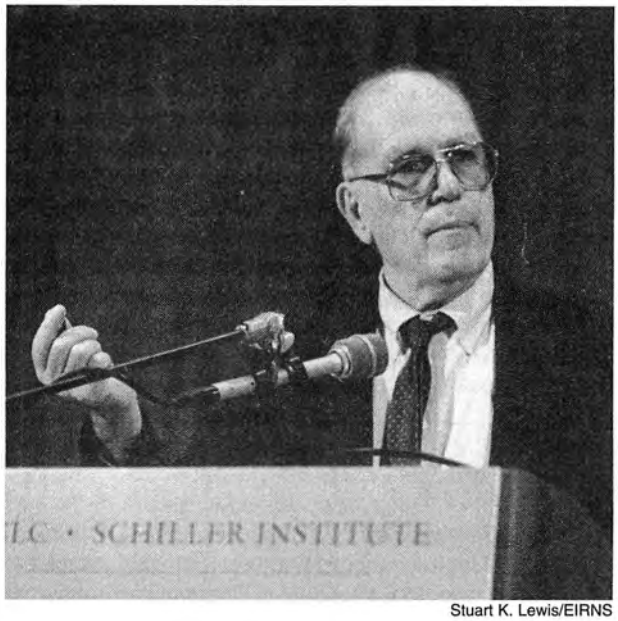
LYNDON LAROUCHE PROPOSES

A 25-Year Solution to the Energy Crisis

by Lyndon H. LaRouche, Jr.

The first step which must be taken, is to put the entire, formerly regulated sections of our nation's energy industry under Chapter 11 bankruptcy protection. This does not necessarily mean putting each entity into bankruptcy; it means putting some entities under Chapter 11 protection immediately, but it also means putting the protective umbrella of Federal and state government threat to provide such protection to any relevant entity, within the domain of maintaining national and regional energy security.

As a leading feature of that use of Chapter 11 methods, bankruptcy reorganization must be conducted to further the aims of immediate reinstitution of former types of Federal and state regulation of the generation, and distribution of the nation's energy supplies, that at prices sustainable by businesses and typical households, and consistent with pre-2000 trends in such prices.



Stuart K. Lewis/EIRNS

Economist, statesman, and 2004 Democratic Presidential candidate, Lyndon H. LaRouche, Jr.

The difficulty in taking those urgently needed forms of corrective action, is not only that deregulation has become, like cocaine, a habit; but that the financial interests associated most closely with the campaign for the election of the present administration, represent chiefly a Southern Strategy-based complex of financial interests which are deeply committed to defending the revenues from activities which are choking California's economy to death at this moment.

If all among those interdependent courses of action are not taken, no real solution to the presently skyrocketting crisis is possible. In that case, the Bush Administration would come to be seen soon as more or less doomed from the outset, hung, so to speak, by the rope which supported its election.

The Franklin Roosevelt precedent is to be understood to be applicable to this case. The mission is to defend national economic security, as the principle of promotion of the general welfare and national security of all of the population and its posterity, defines the meaning of law under our Federal Constitution, absolutely contrary to the errant opinion of some text-offenders among the U.S. Supreme Court justices.

The prices and assured, regulated flow of the stream of electrical and related supplies, must be immediately re-regulated by the standard of pre-1977 precedents. This regulation should be Federal, insofar as interstate commerce or national-security requires, and shall be otherwise left to the states, but with Federal support and guidelines, as needed for coordination among the states.

Presently strong official and related objections to such policies, should not be considered as tolerable excuses for failing take such actions. When the perceived pain is sufficiently acute, as will soon be clear, those objectors who are still capable of rational behavior, will feel themselves under the greatest pressures to become less stubborn in opposing the restoring of regulation. The nation's electorate will demand such changes, and they will be right in demanding that such changes be made promptly, now, before the present crisis becomes impossible to manage under our Constitutional form of government.

These emergency measures of re-regulation must be complemented by a new matrix of combined, short-term, medium-term, and long-term national energy policy.

This proposal by the economist, statesman, and 2004 Democratic Presidential candidate Lyndon H. LaRouche, Jr., is excerpted from a longer written statement, dated Feb. 4, 2001. That statement is a strategic policy study, which locates the California energy crisis in the global and historical context. It identifies the errors of U.S.A. policy-making, dating back 35 years, which led to California and national crises, and examines the changes in the cultural-intellectual environment shaping the present crisis, which are needed to remedy the situation.

The full 20-page study, "On the California Energy Crisis: As Seen and Said by the Salton Sea," appeared in the weekly *Executive Intelligence Review* of Feb. 16, 2001.

Short-Term Energy Policy

For the moment, we must operate on the working assumption that we have presently available to our nation, approximately sufficient capacity for generation and distribution of required energy-supplies. Major generating installations, and their matching grid-system elements, presently require periods in the order of three to five years to install, even if high priorities are assigned to such installations. Increasing of capacity for refining and delivering fuels also requires lapsed time. That means, that only certain marginal adjustments in primary energy-supplies are feasible during the year or two immediately ahead.

The suggestion that floods of fuels or electricity from abroad would overwhelm the price-crisis, is a childish delusion. No cheap theatrical stunts of that sort will work. Saner people will concentrate on managing what we have, while beginning to build for the medium and long term ahead.

For the relatively short-term period ahead, arranging supplementary supplies for critical points in the grids, will be needed, in the manner of shoring up weak points in the dike. This will be applicable to the needs for improvements in the quantity of supplies, and for improvements in spots of less reliable performance within the regional distribution grids.

Among the required priorities, there must be a cautious avoidance of over-reliance on what might be an excessively extensive scope of load-frequency distribution operations. A large degree of local and regional ability to isolate systems from potential calamities in the broader distribution grids, should be considered a national-security priority. "Just-in-time" and "justly barely enough" practices must be avoided, that as a matter of national economic security. There must be built-in slack within the system, both nationally, and regionally; there must be ready reserves available.

We have an analogous, and related case, in the instance of those who propose to expand FEMA and similar capabilities, for dealing with infectious disease emergencies, without recognizing that the post-1973-1975 take-down of the former Hill-Burton health policy, has resulted in the accelerating destruction of the medical capacities, in institutions, actively employed professionals, and health-care policies, which would be a precondition for doing anything significant in the face of a real health-care emergency. The just-never-really-on-time delivery of supplies of flu-virus vaccines, typifies the evidence of possible lunacy, and clearly incompetence, in proposals for special emergency "crisis-management" re-arrangements of that which does not exist to be arranged.

Among included measures, the following are to be considered. The use of jet-engine complexes, as relatively mobile auxiliary power generation for patching up the distribution dike, is typical of the kinds of short-term actions available. The logistics of fuel supplies, for this purpose, is an integral part of that.

Meanwhile, there must not be reliance upon hydroelectric sources to the degree that such uses might undermine the relevant water-management systems' other essential functions. The primary mission of water-management systems, should be water-management, from which hydroelectric generation serves as both an integral feature and a by-product. The environmental impact of drawing down the water reserves, as a way of avoiding government's responsibility for actions which some political interests might not like, is something this nation need not, and should not tolerate.

Medium-Term Policy

The notion of medium-term energy policy is pivoted on the observation that, at present, three to five years is required, to install a completed electrical generating facility of one to two gigawatts average output-capacity. Most desirable, are facilities which would supply process-heat and synthetic fuels, such as hydrogen and methane, for local and regional industrial and other uses.

On this account, medium-term energy policy overlaps long-term policy. The principal generating plants of the system as a whole, are constructed with an intended useful life of about a quarter-century, or longer; major hydroelectric installations significantly longer. These principal installations involve capital expenditures, and related financing arrangements, at rates which should be sustainable in the order of 1-2 percent simple interest, amortizable over long-term periods.

Given the reality of the awful financial

Tennessee Valley Authority

President Franklin D. Roosevelt's creation of the Tennessee Valley Authority is typical of the public sponsorship of large-scale investment in maintenance and improvement of long-term basic economic insfrastructure needed to resolve today's crisis, LaRouche argues. Here, President Roosevelt signs the legislation creating the TVA on May 18, 1933.

crisis threatening our nation's, and the world's banking systems now, the resurrection of an adequate energy-system for our nation, will require a long-term credit facility of a special type, with a special mission-assignment. There must be a Federal authority which coordinates this, and provides Federal credit for facilitating long-term investments in medium-term construction and rehabilitation of generating and distributing capacities.

In connection with this same point, we must not separate national energy policy from its natural relationship to the financial systems of banking and pensions. Regulated systems of national basic economic infrastructure, operating at low simple interest rates, are the broad base of the pyramid upon which to build national economic growth in depth. This pertains to the natural complementarity between the functions of local and regional banking, and the development of the basic economic infrastructure and communities of the region in which the banker's market is most usefully situated.

The U.S. experience of the Reconstruction Finance Corporation and Germany's Kreditanstalt für Wiederaufbau, are models of reference for such rebuilding and long-term development programs.

This has special importance for national banking and other policies at this present time. The perilous conditions of speculation-ridden private banks at this time, and the need to save those banks as functioning institutions, sometimes almost despite themselves, requires that Federal and state government act to foster the growth of a solid new base of bank assets, by aid of which to manage the difficult work of financial reorganization of banking institutions which must not be allowed to fail, even though they be awfully bankrupt.

The fostering of public sponsorship of large-scale investment in maintenance and improvement of long-term basic economic infrastructure, is still, today, the most solid foundation available for mobilizing combined public and private resources for a national economic recovery along lines typified, by the work of the Reconstruction Finance Corporation and the Tennessee Valley Authority, during President Franklin Roosevelt's tenure. Clearly, Federal policy and action now, must reference those highly successful precedents.

In such matters, we must always shape the implementation of any important policy, especially those of medium-term and long-term impact, with regard to their impact upon the so-called "macroeconomic" totality in which such undertakings are situated. The interdependency among large-scale infrastructure programs, regional and local banking, and general community and business development within a region, must be the minimal setting within which infrastructure policies and programs must be defined.

In that vein, consider the following.

The location of prospective such plants, must be subject to Federal, as well as state, local, and private initiatives. In any rational form of U.S. national law and related policy, the requirements for power, as measured in even such raw figures as kilowatts per square meter, are subject to the same types of policy-planning as national railway, waterway, and highway projections. Geography and related considerations indicate where such facilities may lie, optimally, over the decades and generations yet to come.

In such respects, the kind of long-term energy-policy under which directions for medium-term actions are subsumed, resembles long-term general staff planning in the military domain. The indispensable role contributed by West Point graduates, as engineers, in building up the basic economic infrastructure of our nation, is among the experiences which reflect the principles involved.

Medium-term policy in this area must take into account, that since the beginning of the Carter Administration, there has been a catastrophic collapse in U.S. energy national security, as a reflection of the combined failure to develop new generation, and attrition of pre-1977 installations. The coming four years in energy policy, must be directed to clearly concretized goals, as defined from a long-term perspective, in choices of locations and numbers of newly constructed generating capacities and in related improvements in grids.

Also, present policy-making for the medium, and long term, must take into account, that throughout the world, there have been significant, qualitative advances in the standards for types of designs of generating plants. Two implications of this, are not to be overlooked in projecting national energy policy for the medium term.

In this connection, we must also recognize a complementarity between needs for new installations inside the U.S.A. itself, and what should become a growing vast market for such installations in other parts of the world.

Our national policy must foster the resurrection of U.S. capital-goods-producing capacity lost over the recent quarter-century, with the intent of fostering the reappearance of firms which find the base-line for their market in combined domestic and foreign requirements. Such a marketing perspective warrants acceleration of scientific and related technological progress in this field of capital goods production and installations, and indicates a corresponding requirement in even the medium-term programs of our universities and related institutions.

This also points to the need for permanent functions of our Federal government, to bring together the public and private interests and agencies which will contribute crucial parts to implementing such a perspective.

Long-Term Policy and Environment

It should come to be understood, that "long-term energy policy" has two distinct, but complementary meanings for practice. In the first approximation, it signifies the intended cumulative effect of adding generating facilities which each could be installed, usually, during periods of three to five years. It should also mean something distinctly more profound; we should see energy policy in terms defined by the celebrated biogeochemist Vladimir Vernadsky's conception of the *noosphere.*

To make this clear, I summarize Vernadsky's conception, resituating it in the setting of my own original work in physical economy, and correcting some widespread, but incompetent popular opinion on this subject.

Vernadsky is famous for defining the term "biosphere," as signifying that our world's atmosphere, oceans, and much of the surface of the Earth down tens of

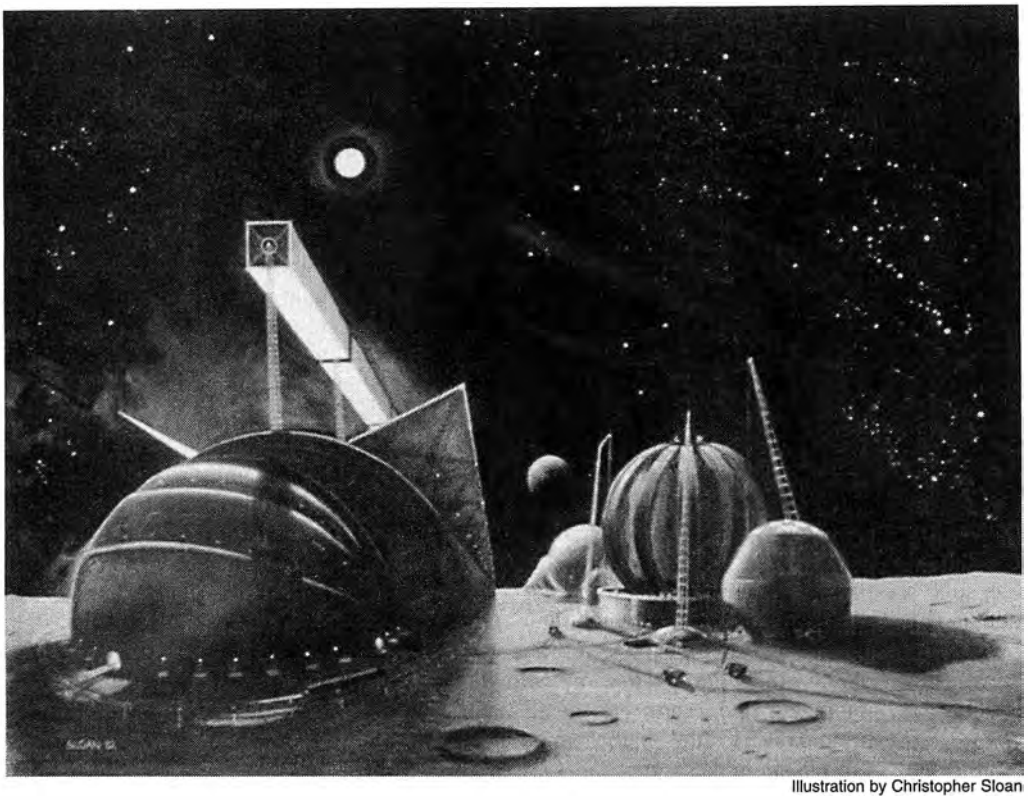


Illustration by Christopher Sloan

Vernadsky's notion of noosphere provides a useful vantage point for considering an important feature of our national long-range mission: space colonization. Shown, an artist's rendition of fusion power plants on the Moon.

kilometers, is, increasingly, the *natural product* of the action of living processes upon the otherwise non-living Earth as a whole. He went further, to emphasize that the rate at which the biosphere itself is growing, is increased by the creative economic activity of mankind. Thus, he defined our planet as, in the first instance, under the reign of a biosphere, which is, in turn, under the reign of a creative force, human creativity. Vernadsky then defined this superimposition of the *noetic* powers of creativity, unique to the human species, upon the biosphere, as through physical-economic activity, as the *noosphere*.

That means, that we must view mankind's development of what we call basic economic infrastructure, as functionally an extension of the biosphere's role in generating and sustaining the preconditions needed for human life.

Therefore, domains of public interest such as mass transportation, water management, improvements of fields and forests, and production and distribution of energy, must be viewed as what Vernadsky would term the *natural products* of the noosphere, just as he classified atmosphere, oceans, and so on, of pre-human Earth, as natural products of the biosphere. From a standpoint of modern economy, the development of general basic economic infrastructure, and our maintenance and improvement of the biosphere, are to be seen as a continuous, single process within the *noosphere*. Among the relevant points to be stressed, is the beneficial role of rational development of basic economic infrastructure in improving what would be otherwise called the biosphere.

This means, that one of the goals of public administration, is to ensure that the land-area of the world is improved, as a biosphere, to the effect of enhancing the conditions required for human life.

To this end, I, in my function as a specialist in the science of physical economy, have introduced a refined notion of what I and my associates have introduced to Eurasian policy-deliberations as "development corridors." This is to be seen as an extension of what American System economists Friedrich List and Henry C. Carey defined as the function of a transcontinental railway system, such as those which integrated the U.S.A., from Atlantic to Pacific, as functionally a single national territory.

If we examine relevant examples from both ancient and modern history accordingly, we should recognize, rather readily, that it is necessary to correlate general transportation routes, with power generation and distribution, and with water management, all under a single, unified conception. By developing corridors of this type, in bands of up to fifty miles or more in breadth, we create the preconditions under which what is economically otherwise more or less marginal land-area within a continental interior, is transformed into highly productive, economically fertile area.

If we approach such pathways of development appropriately, the effect of such development is, to enhance the biosphere for man's existence, not, as many misinformed persons have feared, the reverse.

The present crisis, born out of the follies of U.S. policies (in particular) during the recent thirty-five years, has brought us to the time, that our properly informed concern for the coming generations of our population, should impel us to develop and adopt long-range policies whose effect on the *noosphere,* is to enhance the condition of the nation and the world bequeathed to our descendants.

Lessons From Space-Science

This notion of a *noosphere* coincides with what should be adopted as another leading feature of our national long-range mission. One of the greatest drivers for scientific and technological progress during the course of the Twentieth Century, was developments pertaining to the exploration of nearby

The Deregulation Fraud

Continued from page 43

ny, but from his familial relations with Enron. Enron's CEO, Kenneth Lay, was the major contributor and fundraiser for George W. Bush's 2000 electoral campaign (and his campaigns for Governor, before that), his transition, and even his inauguration festivities. Lay is now an advisor to the Bush Administration on energy policy. In this new administration, economic advisor Larry Lindsay, and U.S. trade representative Robert Zoellick were both advisors to Enron before joining the Bush team.

Commenting to the *Seattle Times* at the very start of deregulation in 1997, Rep. Peter De Fazio (D-Ore.) stated: "Why do we need to go through such a radical, risk-taking experiment? The answer is, there are people who are going to make millions or billions."

That is precisely what the effect of deregulation has been.

The only solution to the "California effect," is to overturn all of the federal and state legislation to "restructure" the electric utility industry, and re-regulate.

Solar space. Most of our leading achievements in science and technology on Earth, have occurred either as by-products of combined military and other space programs, or in symbiosis with them.

For reasons which I have elaborated in other locations, the establishment of a production-facility on the Moon, and the long-term goal of establishing a Los Alamos laboratory-scale of scientific research installation on Mars, pertain to the future security of the planet Earth itself from asteroid threats and numerous other causes. The danger to be averted with aid of such space researches, is not from a child's fancifully fearful images of invading species of malicious living consciousnesses, but from the kinds of natural, biological and other catastrophes which are, at present, built into the design of our Solar system. The evidence, that the cosmic-ray showers impinging upon Earth are traced back, principally, to the highly anomalous Crab Nebula, indicates the classes of problems and possible benefits which a space-oriented science mission must take into account. We might not intend to visit the Crab Nebula itself, during mankind's presently foreseeable future, but we must study it from afar, and examine more closely the effects of that radiation on the characteristics of both living and non-living processes within the inner region of the Solar system, as on Earth itself.

Such relatively long-term missions into nearby Solar space, may be distinctly long-term, involving perspectives of from a quarter- to half-century, but it is clearly necessary, and must necessarily have immediate and continuing benefits to life on Earth, even simply through the use of by-products obtained from such scientific discovery and related development. If there is something "out there," threatening us a half-century to a century ahead, we should get started on the necessary development-work, now. It is such long-view commitments, which separate science and its progress from merely tinkering.

When we consider, from Vernadsky's standpoint, the actual requirements for replicating the micro-environmental equivalent of an Earth-like *noosphere* in a site on Mars, we are forced to look at the relationship among human populations, their *noosphere* and the biosphere in a fresh and valuable way. The very fact, that such a significant portion of our present population, was attracted to concern for the well-being of the biosphere, whether they understood that subject competently, or not, reflects a natural, and healthy disposition for viewing the future conditions for human life as a guiding mission-orientation for the present policy-making of society.

Morality, the glue which holds society together as human, rather than Hobbesian beasts, is not confined to local relations among presently living persons; it lies, more essentially, in the way in which the living moral individual, views the shortness and fragility of his or her mortality, in respect to preceding and future generations of all humanity. It is the passion so aroused, in the individual's reflection upon that relationship to past and future, which is the living bloodstream of true civilized morality.

Thus, it is, sometimes, those missions which may seem intangible to the unthinking person, which imbue the society with the motive for that individual and cooperative accomplishment on which healthy social relations within society depend. It is the passions such a sense of mission imbues, which have proven indispensable, historically, for the most notable efforts on behalf of general human progress.

Government policy-shaping must never become so obsessed with the more obvious practical side of near-term goals, that it loses sight of the role of human motivation in making possible the achievement of any sort of important goal. Without a well-developed sense of mission, well-planned wars are lost in their execution, and capable units fail in their local tasks. Without long-term goals, the motive for simply moving ahead today is weakened to the degree, that even simple obstacles appear to be insuperable, when they might have been rather readily overcome. We must never be so imbued with the mind-set of the financial accountant, that we lose sight of the importance of that which does not appear in his proposed budget, a quality of human motivation, which, in its finest expression, spans the work of generations yet to come.

The New Nuclear Power

IN THIS REPORT

What does a "fourth generation" nuclear plant look like? This report reviews two new reactor designs, which, given the proper political resolve, could be on line within this decade. The need for such new designs—modular, mass-producible, easy to operate, supersafe, and affordable—has never been greater.

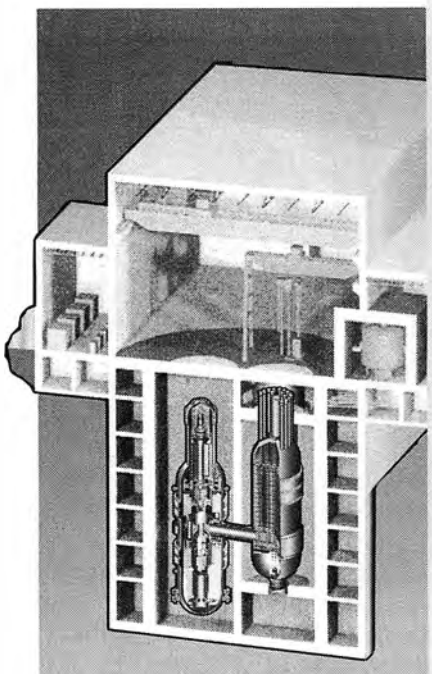
Sixty years after the beginning of the fission age, the enormous potential of nuclear technology is still waiting to be explored and developed. The United States has 103 nuclear reactors, supplying about 20 percent of the nation's electricity, safely, cleanly, and efficiently. No new U.S. reactor has been ordered since the 1970s, largely because of irrationality (as elaborated in the Environment section, "Who Killed U.S. Nuclear Power").

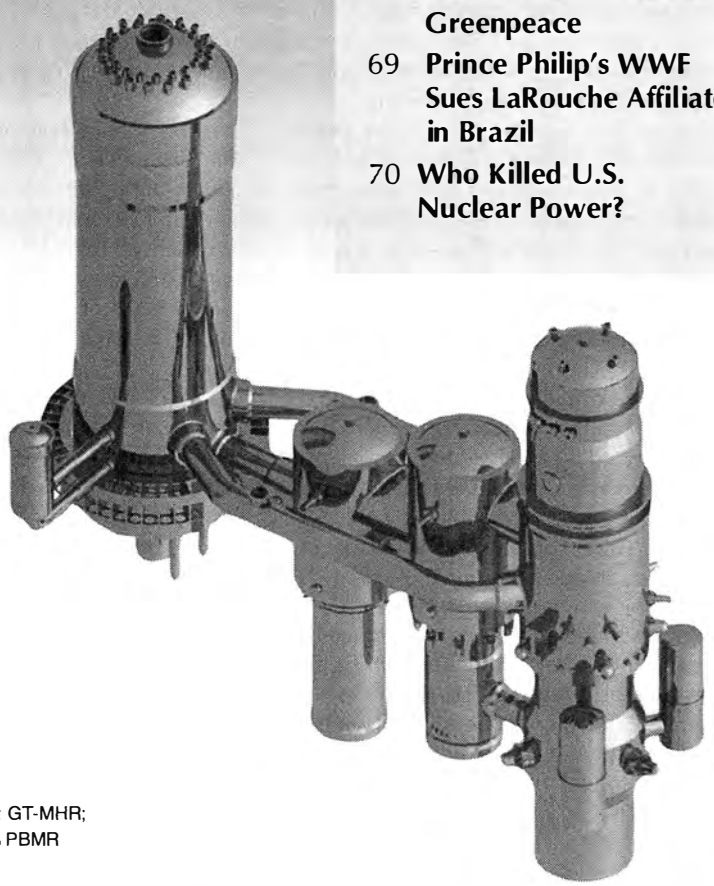
First, there was a massive public relations campaign, funded by the oligarchical interests behind the ecology movement, including Price Philip, Prince Bernhard of the Netherlands, and the huge U.S. foundations, which scared the public about nuclear power. At the same time, the Carter Administration, run by a Trilateral Commission bent on establishing a post-industrial economy in the United States, paralyzed long-term investment with interest rates exceeding 20 percent, and unreasonably time-consuming regulation on nuclear construction. The nuclear industry refused to fight back effectively, and went along with its own destruction, piece by piece.

Over the past 25 years, instead of building the 2,000 nuclear plants by the year 2000, as envisioned by the optimism of the Atoms for Peace program in the late 1950s and early 1960s, the world has only 420 operating nuclear plants, and the United States is in the midst of an energy crisis. But with this crisis comes the opportunity for change. In this issue, we give readers an outline of how we got here, and what we can do to put the next-generation of nuclear plants on line—fast.

The Nuclear Report is followed with the Environment section, which opens with the story of how the Brazilian Nuclear Association, faced with the demise of that nation's nuclear program, fought back against the lies of Greenpeace, and brought the Brazilian nuclear program back to life.

—Marjorie Mazel Hecht





Above: GT-MHR;
Below: PBMR

SAFER, CHEAPER, MORE EFFICIENT

Inside the Fourth-Generation Reactors

by Marjorie Mazel Hecht

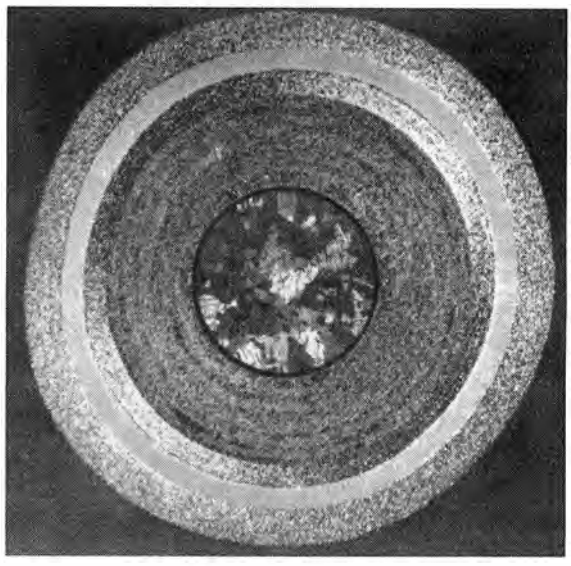
A new, fourth generation of nuclear reactors---the General Atomics GT-MHR and the South African PBMR—is ready to replace the standard reactors that have been producing power for 40 years. These new high-temperature reactors are almost 50 percent more efficient than conventional nuclear reactors, and supersafe.

To understand why, we'll first review some basics of how a nuclear chain reaction is brought about and how it is controlled, so as to produce the heat that turns a turbine to generate electricity.

Fission is the splitting of the atomic nucleus of heavy elements, such as uranium, producing a quantity of heat (in the form of fast-moving particles), that is thousands of times greater than that obtained from burning an equivalent amount of coal, oil, or natural gas.[1] The possibility of uranium fission, suspected by scientists for some years before, was definitively established in 1939. It was recognized right away, that such a great source of energy could serve as a peaceful energy source—or, as a powerful weapon.

When uranium fissions, each nucleus divides into two or more lighter elements (Figure 1). The fission is initiated when the uranium nucleus captures a neutral particle, called a neutron, which has been ejected by another atomic nucleus. The fission process is very fast; after a neutron is freed, it stays that way only for about 1/10,000 of a second. What makes fission so unique as a source of energy is the way it can multiply.

In fissioning, each uranium nucleus gives off two or more neutrons. This means that once the fission process is initiated, it can continue by itself, as the neutrons from each fissioned uranium nucleus trigger new fissions in nearby nuclei. This process is called a *nuclear chain reaction.*



Courtesy of General Atomics

Magnified photograph of a .03 inch fuel particle for the high-temperature reactor, cut away to show layers of ceramic materials and graphite surrounding a kernel of uranium oxycarbide fuel. The fuel will stay intact in its "containment building" up to 2,000°C (3,632°F).

Chain Reactions

The first nuclear chain reaction was achieved during the wartime Manhattan Project, in December 1942. The reactor was called an *atomic pile,* because it was constructed with piles of graphite bricks (40,000 of them) and pellets of uranium, in what had been an underground squash court at the University of Chicago. (See Figure 2.) This was a *controlled chain reaction.* Nothing exploded, but heat was produced—about enough to boil a teakettle of water.

Once the Manhattan Project scientists had proved that it was possible to create a chain reaction, they tackled the more difficult task of producing a nuclear bomb.

The principle of the bomb is the opposite of that of a power reactor. In the bomb, the object is to compress the nuclear fuel, surround it with explosives in a properly shaped geometry, and force the entire, hyperdense critical mass into fissioning all at once—with 2^{80} fissions per second, in a superfast chain reaction.

In a controlled chain reaction, the configuration of uranium fuel must also achieve a *critical mass.* This is the amount and arrangement of uranium necessary to assure that the number of neutrons that cause fissions in other nuclei of uranium, will be greater than the number of neutrons that escape, or are captured, without fissioning. The critical mass depends on the amount of uranium, its purity, and its geometrical arrangement. (Impurities—atoms of other elements—can capture neutrons without fissioning.)

In the simplest case, it is a matter of having a large enough mass of fissionable uranium, so that the neutrons produced don't all escape, or get captured by non-fissionable uranium and other elements, but will bump into other fissionable uranium nuclei and cause new fissions. Remember, the neutrons are neutral particles, and can whiz through the empty spaces in atoms, missing the uranium nuclei, and escaping from the mass of uranium. Critical mass involves a surface-to-volume ratio; where this ratio is minimized (as in a spherical arrangement), more fissions are likely to occur. The objective is to give neutrons less surface area from which to escape without fissioning. (In the Manhattan Project, Enrico Fermi experimented at first by bringing two lumps of uranium together, to see when it began heating up. From there, he moved to larger piles of uranium.)

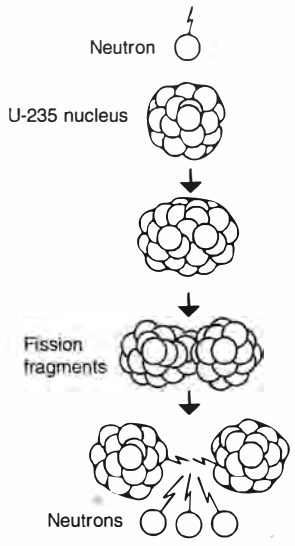
Managing Neutrons

To sustain a chain reaction, each nucleus that undergoes fission must produce at least one neutron that will cause another nucleus to fission. The ratio of the number of neutrons in any one generation that fission, to the number of fissioning neutrons in the preceding generation is called the multiplication factor. The multiplication factor has to be more than 1.

Figure 1
THE FISSION PROCESS

When a neutron hits a uranium-235 nucleus, the nucleus splits apart, producing two fission fragments of lighter elements, and two or three new neutrons.

The "235" in U-235 refers to the number of protons and neutrons in the nucleus. The 92 elements are listed by the number of protons in their nuclei, from hydrogen, which has 1, to uranium, which has 92. The mass number of the element is the sum of its protons and neutrons, which, in the case of fissionable uranium is 235, and in the case of nonfissionable uranium, 238. Each atom of an element has an equal number of protons (which are positively charged), and electrons (which are negatively charged), but the electrons are so tiny as to be counted as zero weight.



The probability that a neutron will penetrate a nucleus to cause fission is known as the *cross section* of the element, and, given the sense of humor of Manhattan Project scientists, cross sections are measured in units called *barns* (one barn is 10^{-24} square centimeters—that's a trillion-trillionth). It comes from the fact that, relatively speaking, some isotopes (like U-235) are as easy to hit as the side of a barn, compared to more difficult target isotopes.

It is possible to configure the uranium in many different ways, including very small fuel particles, arranged in such a way that the free neutrons will trigger other fissions, at a desired rate. Different reactor designs are possible, in which a controlled nuclear chain reaction is able to produce a steady and continuous amount of power, using a (comparatively) very small amount of fuel (see Note 1).

In the nuclear power reactor, depending on its type, natural uranium, or slightly enriched (3 to 5 percent) uranium is used as the fuel. The uranium ore found in nature is made up mostly of the non-fissionable isotope known as U-238. The isotope of uranium which fissions easily is U-235. But, in a sample of natural uranium ore, there is only 1 atom of the fissionable isotope present for every 140 atoms of the non-fissionable isotope. To make a bomb, the natural uranium must be "enriched" to greatly increase the ratio of fissionable U-235 to U-238.[2]

When uranium fissions, neutrons are produced very fast—in a ten-thousandth of a second. You might think that fast neutrons are the ones to produce fission first, but it doesn't work that way. It was found that fast neutrons tend to be "captured," without fissioning, by the U-238. It was only the slower neutrons that caused the U-235 to fission.

The problem then becomes, how to slow down enough of the speeding neutrons to cause enough fissions in order to sustain a controllable chain reaction. Part of the solution, arrived at during the Manhattan Project, was to combine the fuel with what is called a *moderator*, a lighter element of low density, so that neutrons could bounce off it and slow down, without getting captured or escaping.

For even more control of the reaction, lighter elements (like boron or cadmium) were formed into rods, which could be inserted into the reactor core to "control" the reaction rate, by absorbing neutrons. During the Manhattan Project, it was also discovered that certain proportions of fuel, and geometries of arrangement of the fuel, changed the rate of the fission reaction, by making it easier for the neutrons to cause more fissions.

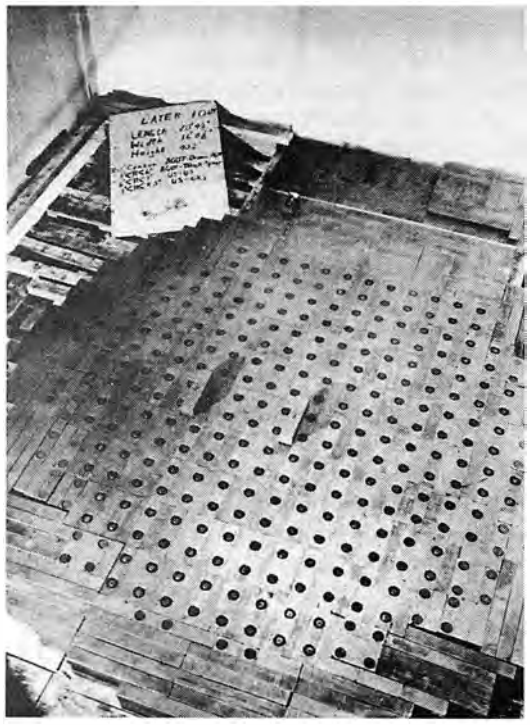
What is required, however, is not only more fissions, but just the right amount to produce a steady reaction at the desired rate. Think of the problem this way: If each fission successfully produced 2 or 3 new successful fissions, the rate of fissions would multiply hundreds of times in a fraction of a second. More gradual rates are needed for a controlled reaction.

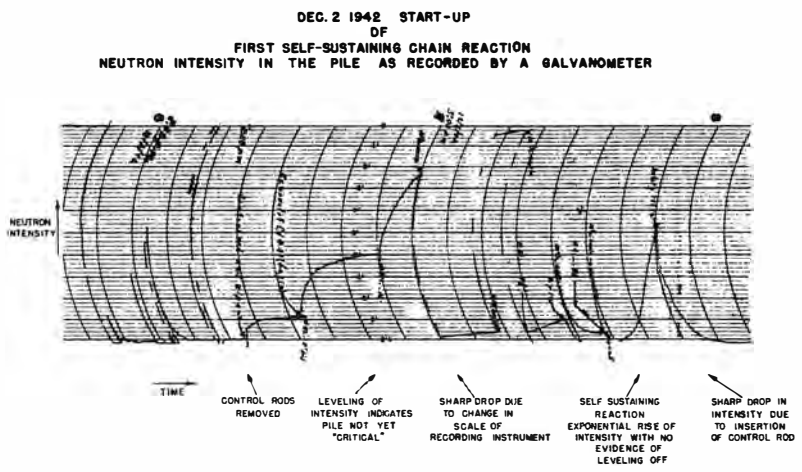
One aspect of neutron physics that helps in this process is that a small percentage of neutrons is not released

Figure 2
THE CHICAGO ATOMIC PILE

This first U.S. "reactor," produced a nuclear chain reaction on Dec. 2, 1942. A circular pattern of bricks of graphite (the moderator) were stacked up in layers. Alternate layers had holes drilled in them to contain uranium pellets. The control rods consisted of strips of cadmium, which were removed by hand. The shape of the pile was intended to be as close to spherical as possible, in order to capture more neutrons (by minimizing the surface-to-volume ratio).

Source: Argonne National Laboratory





Source: Argonne National Laboratory

Figure 3
NEUTRON INTENSITY IN THE FIRST CHAIN REACTION

This is the chart that registered the Chicago Pile's neutron intensity to the point of the first chain reaction. The scale was changed by a factor of 10 (see mid-chart) as the number of neutrons increased. Enrico Fermi, who directed the experiment, had calculated approximately how far the cadmium control rod had to be pulled out before the pile would go critical. The reaction was stopped (by re-inserting the control rod), once that point was reached.

instantaneously with the fission reaction. These delayed neutrons, as they are known, also have to be included in the fission calculation. If the neutron population can be limited so that the delayed neutrons are necessary to keep the chain reaction going, it will help keep the reaction at the desired, gradual rate.

The Chicago pile used more than 6 tons of natural uranium and uranium oxide to create the first chain reaction. It was not certain exactly when the critical mass would be reached, so the control rods—strips of cadmium—were pulled out at intervals, while the neutron activity inside the pile was being measured. At a certain point, there was a sharp increase in the neutron intensity; critical mass was reached, and a chain reaction started (Figure 3). Soon after that point, the control rods were put back in, and the pile was shut down, because it had done its job by proving that a controlled chain reaction is possible.

How a Conventional Reactor Works

There are many kinds of power reactors today, all of which began as ideas during the Manhattan Project—light water reactors, heavy water reactors, breeder reactors, and high-temperature reactors, just to name a few. None of these power reactors can explode, and their fuel cannot be used to make a bomb in its unenriched state.[3]

The conventional nuclear reactor is similar in outline to an oil- or coal-fired power plant. A source of heat (combustion or fission) is used to create steam, which turns a turbine to generate electricity. The most common reactor in the United States is a light-water reactor, either the pressurized-water reactor (PWR) or boiling-water reactor (BWR). (See Figure 3.)

The chain reaction takes place inside a huge, 300-ton pressure vessel, called the reactor core. It is made of carbon steel, lined with stainless steel, and has 9-inch-thick walls. Inside the core is the fuel, moderator, and coolant.

The uranium fuel is processed into uranium dioxide pellets, which are then stacked into 12-foot-long metal tubes, and bundled together into fuel assemblies, each of which has up to 240 rods, in the case of the PWR. The fuel assemblies are arranged so that water, which serves as both the coolant and the moderator, can flow between them. The water does not come in direct contact with the fuel, because the fuel rods are clad in zirconium or another metal. The free neutrons "travel" up to about 3 feet maximum, unless they are captured or fission.

The control rods are suspended so that they can be raised or lowered into the core, sliding between or within the fuel assemblies. Around the pressure vessel is radiation shielding, and a containment building, made of steel-reinforced concrete. There is a system of pipes (called loops) to carry the heated water to the steam generator and back to the reactor core.

As can be seen in Figure 4, the domed containment building, with its thick walls, surrounds the nuclear core and the steam generator, but the rest of the cooling system and the turbine are in other buildings of the nuclear plant.

Inside the HTR

One of the most striking differences of the fourth-generation reactors is that the containment "buildings" for the new modular high temperature reactors (HTRs) are tiny—about 0.75 millimeters in diameter (three-hundredths of an inch). Unlike conventional nuclear reactors, which contain the nuclear reaction in a pressure vessel, surrounded by a thick-walled concrete containment building, each particle of uranium fuel for the HTRs has its own minuscule containment "building."

The tiny fuel particles are coated with several concentric layers of temperature-resistant materials, including silicon carbide and graphite. Inside this containment, the uranium fuel particles undergo fission, but the fission products stay inside; they are "contained" within the ceramically coated fuel particle.

How is it possible to have a nuclear chain reaction, if the fuel is in separate tiny particles, each in its own "containment building"? The neutron behavior is the key. When a fuel particle breaks apart, it releases (a) two to three neutrons, which fly out of the particle at a rapid speed, and (b) two fission fragments, which decay into stable elements of lesser atomic weight, releasing thermal energy (about 200 MeV) in the process. The fission products remain stably contained inside the fuel particles, while the neutrons continue to travel (free neutrons can go about 3 feet).

Some of these neutrons are absorbed without fissioning by the U-238, or by impurities in the fuel, but a few will

cause fission in other fuel particles. The chain reaction is possible, when the number of neutrons that go on to cause fissioning is larger than the number of neutrons that do not.

The Fission Process

The fission process in the fourth-generation HTRs is similar to that in any nuclear reactor. A source of fast neutrons (such as beryllium) in a small pocket in the reactor is made to start releasing a few fast neutrons in the reactor vessel. These neutrons begin to hit the uranium fuel particles, causing some to split apart, releasing fission products and more neutrons in the process. A single neutron-caused fission, produces two or three new neutrons; this is the basis for the chain reaction.

The reactor operators start up the fission process slowly, using the control rods to manage the density of neutron release. The control rods are made of boron, an element that absorbs or slows down these neutrons. As the control rods are slowly removed from the reactor, more and more fissions take place. At first, it might be 10,000 fissions every second—low density; then 100,000 fissions every second. As the individual fuel particles undergo fission, they release heat, until, when all the control rods are pulled out, the reactor reaches its designed heat level—600 megawatts-thermal, in the case of General Atomics' GT-MHR. The reactor is configured to maintain this temperature output on a continuous basis.

As noted above, neutron speed is critical to ensuring that neutrons cause fissions, instead of being captured by non-fissionable U-238. It is the neutrons that are slowed down by collisions with the carbon in the graphite moderator, and the graphite "reflectors" inside the fuel assemblies and on the sides of the reactor core, that have the best chance of causing the fission of U-235. These slower neutrons are called thermal neutrons.

Fuel Configuration

The fuel element configurations for the GT-MHR and the PBMR are different, but the fuel particle containment is essentially the same. In the General Atomics GT-MHR modular reactor, the fuel particles are embedded in 2-inch long, 1/2-inch diameter rods, which are stacked up in columns and inserted into a hexagonal fuel block that has holes drilled into it.

In the Eskom design for the PBMR, the fuel particles are embedded in graphite and formed into tennis-size balls, called "pebbles," which give the reactor its name. In both of these reactors, there are hundreds of thousands of fuel particles.

In the GT-MHR, there is enough uranium fuel in the reactor to keep it going for a year—about 5 tons—and the mix of natural uranium to fissionable uranium is calculated for optimal results. There are also just enough of the "poisons" to keep the neutron flow constant. In the PBMR, the fuel mix is similar, but there is constant refueling; fuel pebbles are cycled through the reactor about 10 times, and then removed.

The fuel particle containment is an important part of the safety of these new rector designs. The silicon carbide and other ceramics that encapsulate the fuel will stay intact up to 2,000°C (3,632°F), which is well above the highest possible temperature of the reactor core, even if there is coolant failure—1,600°C (2,912°F).

This containment design also makes the waste disposal problem simpler. The fission products remain inside the spent fuel pebbles or fuel rods, and thus there is no leaching problem when the waste is stored.

Plant Configurations

Very early on, in the Manhattan Project, scientists and engineers played with ideas for creating reactors that would produce power cheaply and safely. They explored different configurations of fuel, different elements to slow the neutrons, a variety of coolants, and both small and large plant sizes, including some tailored to specific uses and specific sites (the nuclear submarine reactor, for example, or nuclear propulsion).

Each type of reactor makes use of the same basic principles: splitting uranium atoms to release neutrons, high-energy particles that sustain the chain reaction. But, how the heat of the reactor is utilized differs in the conventional reactors and the fourth-generation HTRs.

In a pressurized water reactor, one of the most common types of conventional reactors, there are three sets of pipes, called loops. In the first loop, pressurized water (at about 600°F) is pumped through the reactor and then to the steam generator. Once in the generator, cooler water from a second loop, not under so much pressure, surrounds the first loop water pipes, and is heated by

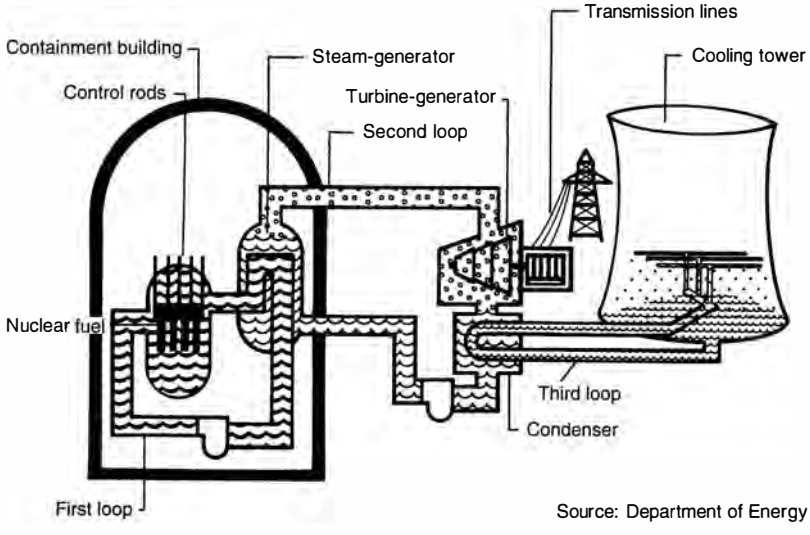


Figure 4
SCHEMATIC OF A PRESSURIZED WATER REACTOR
Except for the heat source (fission), this nuclear reactor works much like a power plant fired by coal or oil. Heat is produced, which makes steam, which turns a turbine, which generates electricity. In the pressurized water reactor, water is both the coolant and the moderator.

it, turning to steam. The second loop carries the steam to the spinning turbine, which is attached to a generator, where the mechanical energy of the turbine is transformed into electrical energy.

After losing its heat energy, the steam in the second loop goes to a condenser, where it is cooled back into water by a third loop, which contains cooling water that comes from a river, the ocean, or a cooling tower. The second loop transfers its heat to the third loop, and the water in the third loop is then pumped to a cooling tower, where some of the heat is removed.

In these fourth-generation reactors, however, the heat, conveyed by the helium gas, is *directly converted* by a gas turbine to produce electricity, entirely eliminating the steam cycle (and making these reactors very cost-efficient).

The concept of the pebble bed high-temperature gas-cooled reactor dates back to 1942, just around the time of the first atomic pile at Chicago University. Chemist Farrington Daniels came up with the idea, and after the war, at Oak Ridge National Laboratory, he headed a team that worked up a pebble bed design that was supported by the Army Corps of Engineers. At the time, the concept was dropped, in favor of the pressurized water reactor, and the group that worked with Daniels went on to design the first nuclear reactor for the *Nautilus* submarine.[4]

Later, Great Britain, Germany, and the United States developed high temperature gas-cooled reactors. The Germans pioneered the pebble bed design, developed by Prof. Rudolf Schulten, and built and successfully operated the AVR Reactor in Jülich from 1966 to 1988.

The Helium-Coolant

The concept of helium gas as a coolant also dates back to the Manhattan Project, where it was selected because it is inert and does not react chemically with any part of the fuel or reactor components. Unlike water, which changes from liquid to steam, the helium coolant remains in the gaseous state, and does not corrode the reactor parts.

It is the helium that is referred to as the high-temperature of the HTR, not the nuclear fuel. Helium can be heated to higher temperatures than water, and so the outlet temperature of the new HTRs is 1,562°F—compared with the 600°F of conventional plants—and can be used by a wide range of industries as process heat for desalination, steel making, production of hydrogen, and so on.

The helium circulates through the nuclear core, and conveys the heat from the reactor through a connecting duct to the turbine. As it passes through the compressor system, it is cooled to 915°F, and it reenters the nuclear core. Using helium both as the coolant and as the gas that turns the turbine eliminates much of the equipment and expense of conventional nuclear reactors.

Safety Systems

The safety systems for the fourth-generation HTRs are simple, making these reactors "meltdown-proof." The reactors are designed to shut down on their own, and dissipate the core heat without any release of radioactivity, in any conceivable accident scenario (this is called "passive safety"). No human intervention is needed. This is possible, even if all the cooling systems fail.

The containment of the fuel particles, as noted above, is a unique component of the safety. Another of the built-in safeguards is known as the "negative temperature coefficient" principle, and has to do with the properties of neutron capture. If the operating temperature of the reactor goes up above normal, the neutron speed goes up, and more neutrons get captured by U-238 without fissioning, in effect, shutting down the chain reaction. Thus, the design of the reactor itself prevents a crisis without human intervention.

In addition, certain amounts of "poisons" (for example, the element erbium) present in the reactor core, will aid the process of grabbing neutrons without fissioning, if the operating temperature goes up.

Even before these built-in safety features go into effect, the first line of safety in regulating the fission reaction, are the control rods. If they should fail, spheres of boron, an element which absorbs neutrons without fissioning, are released via gravity into the core to stop the fissioning.

Other lines of safety include two external cooling systems—a primary coolant system and a shutdown coolant system. But even if both of these fail, there are cooling panels on the inside of the reactor walls, which use natural convection to remove the core heat to the environment. And even without that, because the reactor is located below ground, the natural conduction of heat will ensure that the reactor core temperature doesn't go above 2,912°F (1,600°C)—well below the temperature at which the fuel particles will break apart.

The graphite moderator also helps dissipate heat in a shutdown, and remains intact up to 4,500°.

A German prototype for the pebble-bed reactor, the AVR test reactor at Jülich, operated for 22 years. In one test, the cooling systems were completely stopped and the control rods removed, while the AVR was operating. The AVR shut itself down in just a few minutes, with no damage to the nuclear fuel: In other words, no meltdown was possible.

The Direct-Cycle Turbine

The design for a simple Brayton direct-cycle gas turbine was pioneered at MIT in the 1980s, for use with the pebble bed and the General Atomics HTR. Direct cycle gas turbines increase the efficiency of the reactor by 45 to 50 percent, thus reducing the cost of power production.

Technological breakthroughs in the past few years, have contributed to the overall efficiency. For example, the turbines developed for jet engines like the Boeing 747; compact plate-fin heat exhchangers that recover the turbine exhaust heat at 95 percent efficiency; and magnetic bearings that are friction free, eliminating the need for lubricants in the turbine system.

Notes

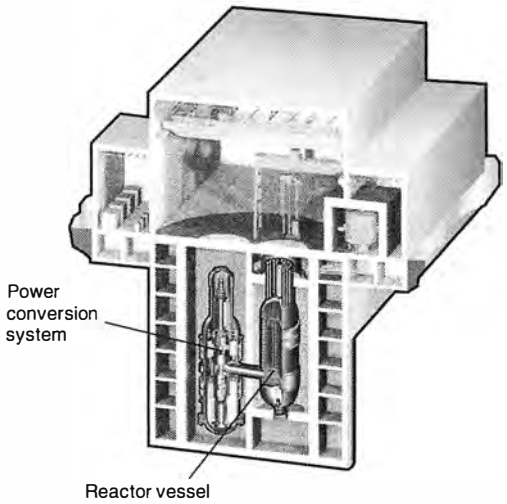
1. One cubic foot of uranium has the same energy content as 1.7 million tons of coal. 7.2 million barrels of oil, or 32 billion cubic feet of natural gas.
2. The process of enrichment is called isotope separation. Developing a large-scale working separation method was a major, energy-intensive effort, during the Manhattan Project, requiring what was then the largest power plant in the world (built at Oak Ridge, Tenn. in just two years) to get the job done. It was also figured out how to create quantities of the fissionable plutonium-239 from the fission products of uranium.
3. But what about Chernobyl? someone might ask. There was not an explosion at Chernobyl, but a power surge caused by a combination of operator errors and bad reactor design features, which destroyed the reactor. Some of the design problems: The RBMK Chernobyl reactor, unlike conventional U.S. reactors, does not have a thick-walled containment structure. It also has has what's called a "positive void coefficient," which means that when the reactor temperature goes up, more fissions occur. The RBMK does not have a capability for rapid shutdown.
4. Manhattan Project veteran Alvin M. Weinberg describes this in his autobiography, *The First Nuclear Era: The Life and Times of a Technological Fixer* (Woodbury, N.Y.: American Institute of Physics Press, 1994).

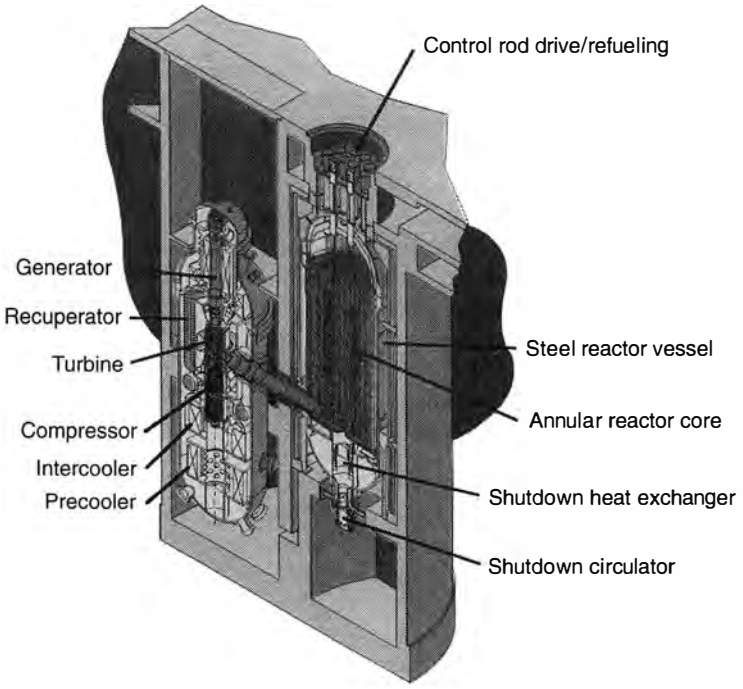
A Meltdown-Proof Reactor: The General Atomics GT-MHR

Figure 1
CUTAWAY VIEW OF THE GT-MHR REACTOR AND POWER CONVERSION SYSTEMS

This is the current design for a 285 MW-e power plant (600 MW-thermal), and shows how the layers of hexagonal fuel elements are stacked in the reactor core. The helium gas passes from the reactor to the gas turbine through the inside of the connecting coaxial duct, and returns via the outside.

The reactor vessel and the power conversion vessel are located below ground, and the support system for the reactor are above ground.





Source: General Atomics

The fourth-generation Gas Turbine Modular Helium Reactor (GT-MHR), under development by the San Diego-based General Atomics company, is a highly efficient helium-cooled high-temperature reactor (HTR), with inherent and passive safety features that make a meltdown impossible. Its tiny fuel particles are encased in ceramic spheres, which serve as "containment buildings" for the fission products. The overall design prevents the reactor from ever getting hot enough to split open the tiny ceramic spheres that contain the fuel.

The GT-MHR produces higher process heat (1,560°F), compared to the 600°F limit of conventional water-cooled nuclear reactors), allowing greater electric generating efficiency, and a wide range of industrial applications, from making fertilizer to refining petroleum. It uses a direct conversion gas turbine to produce electricity, thus simplifying the reactor system and increasing efficiency.

The 285-megawatt-electric reactor is small enough to be mass produced in standardized units, thus making the cost very competitive.

How the GT-MHR Works

The GT-MHR reactor consists of two steel pressure vessels, one for the reactor system, and the other for the power conversion system, both of which are housed below ground in a concrete building (Figure 1). Above ground are the refueling machine for the reactor, and the auxiliary systems for operating the reactor.

Fuel system. Tiny fuel particles that are shaped into finger-sized rods are stacked into a column, and then inserted into the hexagonal fuel element block (Figure 2). The GT-MHR is designed to burn uranium fuel, or plutonium.

The cylindrical reactor core is made up of stacks of hexagonal fuel element blocks of graphite (each about a foot wide and three feet long), into which fuel rods are inserted in vertical columns. The core is ring shaped (annular). It has 61 columns of graphite reflector blocks at the center, 102 columns of fuel blocks surrounding the center, and a ring of unfueled graphite blocks near the outer rim. There are also helium coolant channels in the fuel elements.

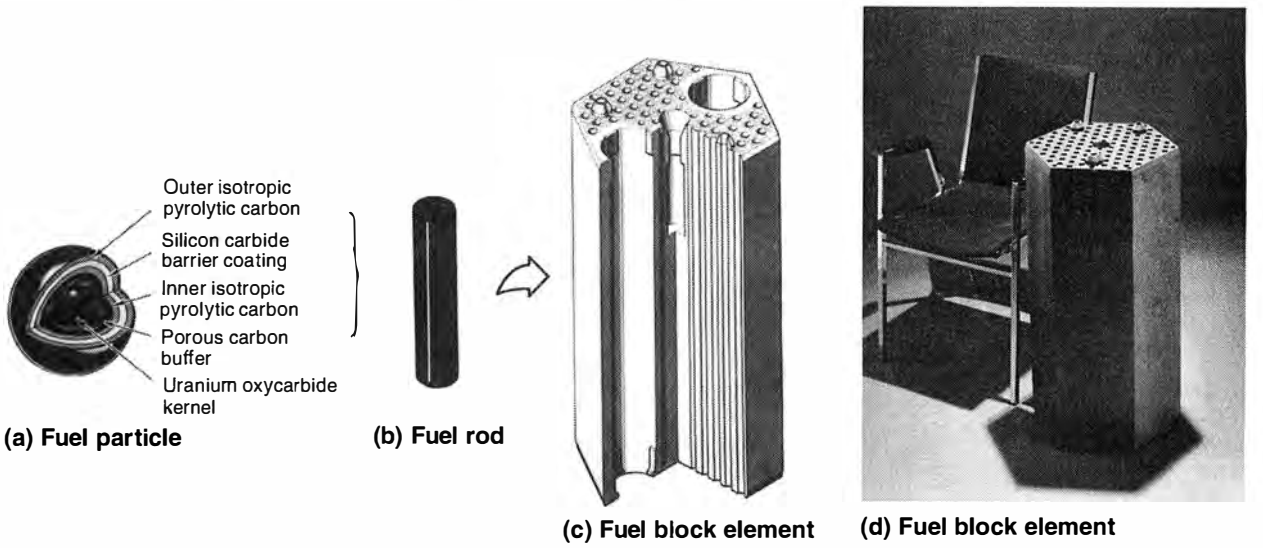


Figure 2
GT-MHR FUEL COMPONENTS

The tiny fuel pellet (a) is about 0.03 inch in diameter. At the center is a kernel of fissile fuel—uranium oxycarbide. This is coated with a graphite buffer, and then surrounded by three successive layers, two layers of pyrolytic carbon and one layer of silicon carbide. The coatings contain the fission products within the fuel kernel and buffer. The fuel particles are mixed with graphite and formed into cylindrical fuel rods about 2 inches long (b).The fuel rods are then inserted into holes drilled in the hexagonal graphite fuel element blocks, (c) and (d). These are 14 inches wide and 31 inches long. The fuel blocks, which also have helium coolant channels, are then stacked in the reactor core.

Source: General Atomics

In the three-year fuel cycle of the GT-MHR, refueling takes place for half the core every 18 months. (In the Pebble Bed, the refueling is continuous.)

Because the annular core has a higher volume-to-surface ratio (as opposed to the Pebble Bed arrangement), higher power levels are possible.

Helium coolant: The helium gas flows down through the coolant channels in the fuel elements, mixes in a space below the core, and then carries the reactor heat through the inside of a connecting co-axial duct to the power conversion system. It circulates through the power conversion vessel, and returns back to the reactor vessel via the outside chamber of the connecting co-axial duct. The helium enters the reactor core at 915°F, and is heated by the nuclear reaction to 1,562°F.

Safety systems: Control rods at the top of the reactor vessel regulate the fission reaction. The rods are lowered into vertical channels in the center and around the rim of the core. If the control rods fail, gravity-released spheres of boron automatically drop into the core to stop the fissioning.

There is a primary coolant system and a shutdown coolant system. If these systems both fail, the reactor is designed to cool down on its own. There is a passive back-up system, whereby core heat is transferred by natural conduction to the reactor walls which naturally convect the heat to an external sink. The concrete walls of the underground structure are lined with water-cooled panels to absorb the core heat from the vessel walls. Should these panels fail, the concrete of the structure alone is designed to absorb the heat. The natural conduction of heat to the underground structure surrounding the reactor will keep the core temperature below 2,912°F (1,600°C), which is well below the temperature at which the fuel particles can break apart, releasing fission products or other radionuclides—3,632°F (2,000°C). The graphite blocks retain their strength up to temperatures of 4,500°F.

In any type of loss-of-coolant accident, the reactor can withstand the heat without any operator intervention.

Increased Efficiency

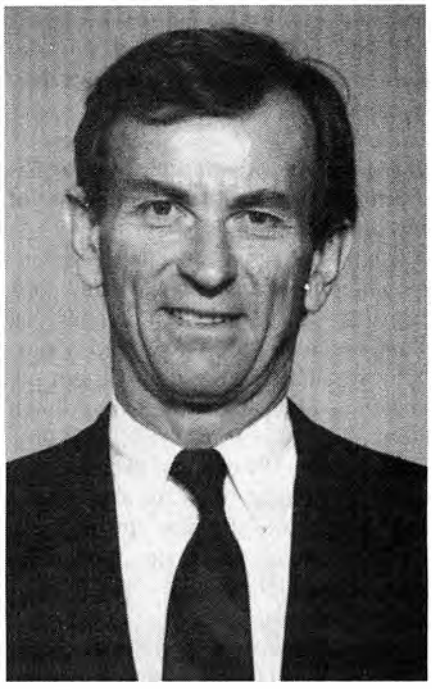
The GT-MHR system efficiency is about 48 percent, which is 50 percent more efficient than the conventional reactors in use today. Its increased efficiency comes from its use of recent technological breakthroughs: new gas turbines developed for jet engines like that of the Boeing 747s; compact plate-fin heat exchangers that recover turbine exhaust heat at 95 percent efficiency; friction-free magnetic bearings, which eliminate the need for lubricants in the turbine system; and high strength, high-temperature steel vessels.

GT-MHR design work is going on now in Russia, in a joint program also supported by the French company Framatome and Japan's Fuji Electric. The Russian-built prototype is designed to burn weapons plutonium as fuel, thus destroying it.

—Marjorie Mazel Hecht

INTERVIEW WITH LINDEN BLUE

General Atomics GT-MHR—Ready to Go in 6 Years



Linden Blue is vice chairman of General Atomics, a San Diego-based company that is developing a modular high-temperature gas-cooled reactor, the GT-MHR. He was interviewed by Managing Editor Marjorie Mazel Hecht in January.

Question: General Atomics has had a joint program with Russia for developing the design for a fourth-generation nuclear reactor, the modular high-temperature reactor (or GT-MHR) for some time. How is it going?

The Russian program is going extremely well. There are now about 600 Russian scientists and engineers working on the project. They have consistently exceeded objectives in terms of schedules, and work accomplished, for the amount of money provided. Their work is of first-rate quality, and we are very pleased with how the design is evolving.

As you may know, the first expected site is to be Tomsk 7, which is one of the former nuclear cities. The reactor there would have the purpose of providing electricity, and district heating, and also destroying weapons plutonium. It would be an extremely efficient destroyer of plutonium, because it would destroy the plutonium while it was providing electricity. The value of the electricity would more than pay for the cost of the reactor.

Question: How large is the initial design?

It is 600 MW thermal—285 MW electric. That size has evolved over time as the *maximum size* we can have, a big factor in economy, while still having the *maximum safety* characteristics—meltdown-proof safety. Meltdown proof safety is critically important to us.

Question: Is it also the maximum for the modular production of the reactor?

Yes, I would say so, as a practical matter. As you may recall, our first modules were considerably smaller. We were always fighting the electricity cost problem. The combination of 285 MW-electric modules and the safety characteristics seems to be the optimum. We will still have all the benefits of modularity, the benefits of the meltdown-proof safety, and costs which are competitive with the largest light-water reactors. In fact, we think the costs may be more favorable.

The reason is that this design is about 50 percent more efficient than current light-water reactors. We are at 48 percent efficiency, and current light-water reactors are around 32 to 33 percent. So, this is a big improvement, and when the reactor is that much more efficient, you are able to spread your costs.

The good thing is, that the further we get into this design, the better it looks, and the more probable it is that we'll be able to achieve those objectives.

Question: When do they expect to construct the design prototype?

We are hoping to have power beginning in 2009. The preliminary design is supposed to be completed in December of this year, and so we could be able to start site work as early as three years from now.

Question: How is the project being financed?

It's being sponsored by the U.S. Department of Energy, European companies (Framatome is our partner in France), and Japanese interests (Fuji Electric). The U.S. Department of Energy, next year, is funding the project with about $10 million. So, it's an international project that is not only going well, but is producing a result that is superior economically. Because of the favorable costs of Russian scientists, we're able to do it less expensively than we could in the United States.

Question: Could you accelerate the time it takes to bring the reactor on line?

A little bit, perhaps—we would certainly like to do that—but it would be subject to funding. There are also limits as to how much you can accelerate.

Question: Right now you're in San Diego, California, in the middle of an ongoing electricity crisis. Do you see a future role for the GT-MHR in this situation?

Yes, I do. I only wish that we had the reactors ready to go right now, while everybody is looking for a solution; unfortunately, our solution is further out in time. But, assuming that the California economy stays strong, California is not only looking at a short-term problem, but a long-term problem. And I think that our reactors will be an excellent solution in the long term.

The reason that they'll be such a good solution is because of their economics, but, even more important, because of their safety characteristics. This makes an undeniable case that this is a better source of energy, particularly when you consider all the environmental bene-

fits—such as not having waste coming out of a chimney. Because of the reactor's efficiency, you even have less thermal discharge.

Question: The situation for nuclear has drastically changed, I think, because of this deregulation crisis—

I think that's true. In many respects, it's unfortunate that people can't look farther ahead. It was very obvious that we were getting ourselves into a box, both in reliance on Middle Eastern oil, and on natural gas. It was obvious, but it takes a crisis to get anybody to do anything about it. With some exceptions—Senator Domenici (R.-N.M.) and Senator Ted Stevens (R.-Ak.) saw the problem coming several years ago, and have been doing a lot about it.

Question: Now we're seeing state legislators and local officials who are saying, "How fast could we get nuclear power plants on line?" That's a very big change.

It's a sea change. . . . it's amazing. But very gratifying. When there is a problem, people have to ask serious questions, and they want serious answers. When they ask serious questions, they learn that that there is a better way to do nuclear, and that nuclear is a superior form of technology from both environmental and cost standpoints.

Question: It seems to me that the industry, although it's moved slightly ahead, is still lagging behind this sea change, and that the situation requires some bolder moves.

If you'd spent the last eight years in the bunker, as we have, you'd be a little bit shell-shocked. . . . but I agree that we do have to be bold. Some people who defend the status quo, can't stand the virtues of new technology. . . .

Question: The U.S. utility Exelon is considering design approval for the modular high-temperature gas cooled reactor, one with a pebble bed fuel system, developed by Germany, and adopted last year by the South African utility Eskom for mass production. What do you think of this design?

We think it's very good and we're supportive of it, and we're all for anybody who's doing anything with the gas-cooled reactor, because the safety characteristics that gas reactors have, in terms of being meltdown-proof will be as good as ours. So, we think that the PBMR is good, and we support it, and we think that there's probably some synergy, in terms of more people recognizing the virtues of the gas reactor.

We have had pebble bed designs ourselves, and believe that they're good, even if we have a preference for the block design.

Question: Can you describe the difference in the fuel systems that give the pebble bed its name, as opposed to the block design of the GT-MTR?

Well, in the pebble bed, the fuel particles are made up into graphite balls, about the size of a billiard ball—a little bigger—and these are loaded into the core. The pebbles move, over time, from top to bottom, where they come out of the core. So, there is a continuous fueling process. The pebble bed, is somewhat limited to the amount of power you can have in each module while still having the safety characteristics.

So, when we examined the pebble bed as an alternative to the block approach, we found it attractive in that it is continuous fueling, but our final determination was that, with the potential for going larger in the module, we would be gaining some cost advantages.

We believe both block and pebble are good, and we're glad to see the South Africans and Exelon encouraging this technology.

Question: What is the limit to the size of the pebble-bed approach?

I think they are talking about a 112 MW-electric as a limit.

Question: So your reactor design is about two-and-one-half times as big. . . .

Yes. The original German designs were around 85 MW, so Eskom has made some improvements to get up to the 112 MW. So far as I know, that's about the practical limit for pebble modules.

Question: In this country, the nuclear wisdom has always been that size made the efficiency, and the economic sense. Do you see that as changing?

I think that there are two factors that go into the efficiency and the economy. One is size, but size up to the point that you don't lose your safety characteristics, because when you get beyond a size that can give you meltdown-proof safety, then you have to add all kinds of extra systems that are very expensive, complicated, hard to predict an hard to license. The combined effect is to run the cost way up. What we've tried to do is meet the point of the maximum permissible power under the meltdown-proof safety criterion. That's where we are, at 285 MW electric.

Question: If this country is actually going to develop, we're going to need a lot of power, and it seems to me that modular standardized reactors are the way to go.

Yes, we think that too, and we are delighted to have a prospect of sharing the market with the pebble bed.

Question: What are the possibilities in the United States of using the modular concept to put new reactors on the same sites with decommissioned reactors, and then add to them?

The possibilities are good. You could put them at existing light water reactor sites. Usually there is plenty of land around them—they are not space limited. One of the big differences with the modular gas cooled reactor is that you don't need to have a big evacuation space around it, the way you do with water reactors.

Question: How quickly could you start turning out standardized modular reactors?

I think we could start the production line in about six years, something like that. There would be a strong desire to have the prototype up and operating successfully before having a large number coming down the production line.

Question: Six years isn't so long. . . .

Once the design is complete, we will

Linden Blue (right) discussing GT-MHR technology in China: "Science is how we are currently providing for the 5 billion population we have . . . and we have a bigger task than ever before to provide for the doubling of population that we are going to see over the next century."

have tested enough of the componentry to know that it's reliable and dependable and therefore that we can go ahead and start up the production line and have a continuous run after the first production module.

Question: So, once the first production module comes up the line and is operating, you would go into high gear. I think that South Africa intends, by the year 2015, to produce 30 reactors. . . .

I would say that's a reasonable objective on their part, and I would say that we could probably be producing that many as well. The difference is that our modules would have the potential for producing more power.

Question: What about the potential world market, in particular, getting the high temperature reactors to the developing sector?

It's very desirable, because this technology is so forgiving of human error. Literally, human mistakes can't make it melt down. That's a great virtue anyplace in the world, but particularly in developing countries, where they don't have an extensive technical infrastructure. The modules that we produce would be transportable anywhere in the world, and you'd rely on local industry to do the concrete and steel work, the civil engineering.

Question: So, you would ship the insides of the reactor, the core?

We'd ship the reactor module and the power conversion module. At some sites, we might weld the reactor vessel on site, but for most sites, we'd just make them in the factory and ship them out.

Question: Where would the factory be?

We believe it should start in Russia. So long as they have the capability of doing the production that's a good place to do much of the componentry.

Question: They certainly have the skilled people available.

Yes, they also have good industrial infrastructure, and a great will to do it.

Question: So, if we can turn around the worldwide collapse, we have a chance. . . . Now, what about the weapons plutonium question.

As you know, the destruction of weapons-grade plutonium is a big issue—a relatively uncontroversial one. Inasmuch as it is important to destroy weapons plutonium, it would be very desirable to use this program to launch the superior fourth-generation reactor. All too frequently, objectives are separated and there become two projects when one could do both. The result is that it costs twice as much.

Question: The antinuclear people are insane on this question. They don't want plutonium as fuel, because that will continue the nuclear cycle.

In our case, we accomplish what the anti-nuclear people want because we destroy the plutonium.

Question: But what the antinukes are afraid of, is that if you have more nuclear power, it will enable you to increase population—and they don't want that. They don't want more people, and they don't want material advancement.

The truth is, that birth rates decline, as people become more productive and wealthy. The highest birthrates in the world are where there is poverty–where there is no energy.

Question: Yes, although that's begun to change now, because people are dying at such great rates, from war and disease. There is actually a downturn in Africa, for the first time.

In Russia that is true as well but it is not true in China, India, and Bangladesh. . . .

Question: Energy is very much tied to more and better jobs, and prosperity, as we see in California now, with this crisis.

It's important that we in the United States take full advantage of the development of this technology for power production. We're getting it paid for, if you will, by the plutonium destruction mission in Russia, which is very good. We hope the U.S. will also take advantage of this technology to produce electricity.

South Africa's Supersafe Pebble Bed Reactor

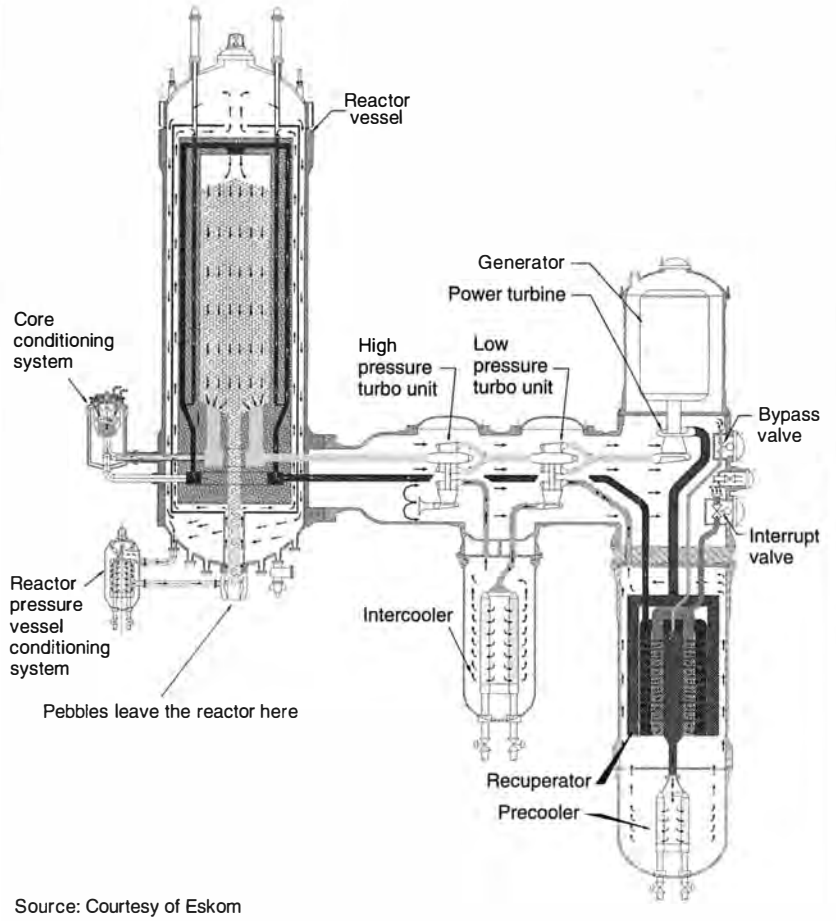
The Pebble Bed Modular Reactor (PBMR) now under development by South Africa's electricity company, Eskom, is a 110-megawatt-electric design. This type of high-temperature reactor was developed in Germany, but Eskom is adding new technologies, such as the direct-cycle helium turbine, to make the reactor more efficient.

To reach higher powers, Eskom envisions siting as many as 10 PBMR units at one location, with a common control room. Because of its small size and low cost, the PBMR is an ideal design for developing nations, which have electricity grids that may be too small, initially, to handle a larger plant. These countries or regions can add PBMR modules as needed.

Eskom anticipates exporting PBMR modules—up to 30 a year—once the program for mass production is under way. Because of the economies of mass production of standardized modules, Eskom has estimated a total cost of PBMR-generated electricity at below 1.6 cents per kilowatt hour. (Now, most U.S. consumers are paying 8 cents, or more, per kilowatt hour.)

Eskom's partners in the PBMR project include South Africa's Industrial Development Corporation, British Nuclear Fuels Limited, and the U.S. company, Exelon (see accompanying article).

CUTAWAY VIEW OF THE PBMR



Source: Courtesy of Eskom

The Design

The steel pressure vessel of the PBMR (see figure) is 6 meters in diameter and about 20 meters high, inside a building that is 21 meters below ground. The walls of the vessel are lined with 100-cm thick graphite bricks. Inside the vessel are 310,000 fuel balls ("pebbles") which are the size of tennis balls, plus 130,000 graphite balls, which moderate the reaction.

Each fuel ball contains about 15,000 fuel particles and about 9 grams (about one-quarter ounce) of uranium. The total uranium fuel in the reactor is 2.79 tons. Each fuel pebble generates about 500 watts of heat, when the reactor is in full operation. The reactor is continuously refueled, with new fuel balls added at the top, and spent fuel balls removed at the bottom. Each fuel ball passes through the reactor about 10 times over its lifetime. The continuous refueling eliminates the weeks-long down-time necessary for large light water reactors, when they are refueled.

The fuel particles, which were pioneered by General Atomics in the United States in the 1950s, are constructed with a tiny particle (0.75 mm) of uranium dioxide at the center, surrounded by several concentric layers of temperature-resistant materials—porous carbon, pyrolytic carbon, and silicon carbide (Figure 2). These coatings "contain" the fission reaction of the uranium, even at very high temperatures (up to 1,600°F). In fact, the fuel pebbles can withstand temperatures at which the metallic fuel rods in conventional light water reactors would fail.

How It Works

To produce electricity, helium gas at a temperature of about 500°C is inserted at the top of the reactor, and passes among the fuel pebbles, leaving the reactor core at 900°C. From there it passes through three turbines, the first two driving compressors, and the third the generator. There, its thermal expansion is transformed into rotational motion to generate electricity. The expanded helium is then recycled into the reactor core by two turbocompressors. The helium leaves the

Continued on page 62

Will the Pebble Bed Come to the U.S.A?

Plans in the works to bring the Pebble Bed Modular Reactor to the U.S. power grid have sent a wave of excitement through the U.S. nuclear industry, which has not had a new plant ordered for decades. Whether it will happen, however, depends more on the outcome of financial power plays under the crazy new deregulated market, than on rational decisions about electric power needs.

Exelon, a new U.S. energy giant, announced last year that is is considering building a South African designed PBMR reactor here. In October 2000, the Philadelphia-based PECO merged with Commonwealth Edison-Unicom of Illinois to become Exelon. The new company owns 17 nuclear reactors—20 percent of the U.S. nuclear fleet.

A few months before the merger, PECO had begun looking at the PBMR, and now Exelon owns a 12.5 percent share in the South African project of Eskom, the government-owned utility, which designed the PBMR. In November 2000, Exelon's president and CEO, Corbin McNeill, who formerly headed PECO, told a meeting of the American Nuclear Society in Washington, D.C., that the PBMR is "the nuclear option of the future."

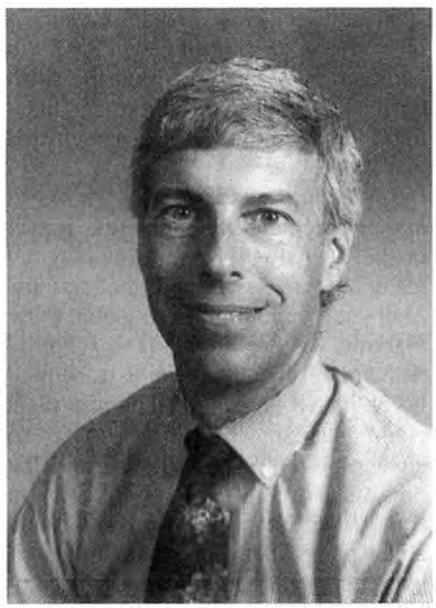
Decision a Year Away

South Africa's Eskom will complete a detailed cost estimate and feasibility study in June 2001, based on its preliminary reactor design. Then, according to Ward Sproat, Exelon's Vice President of International Projects, Eskom's partners in the venture, including Exelon, "will make their decisions on whether to proceed with the next phase of the project, which is the building of a demonstration plant in South Africa."

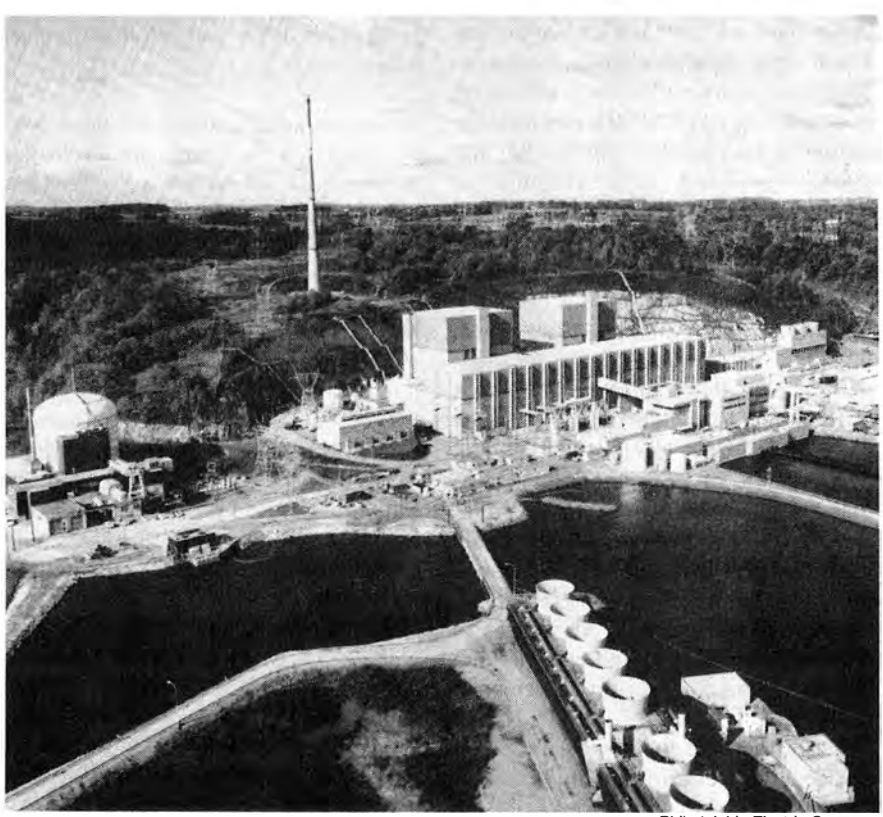
Mr. Sproat, a nuclear engineer who worked for 25 years with PECO, before it became Exelon, expressed caution about the future of a U.S. PBMR. "We are about a year away from making a decision as to whether or not to begin the approval process to build a plant in the United States," he said, in a Feb. 2 interview.

The company has had experience with HTRs. PECO operated the first U.S. high-temperature gas-cooled reactor, Peach Bottom 1, which successfully produced electricity in Pennsylvania from 1967 to 1974. In addition, Mr. Sproat worked with the Gas Cooled Reactor Associates in La Jolla, Calif., in the late 1970s.

Mr. Sproat said that after the company saw reports in the trade press about Eskom's plant, he and PECO chairman and CEO, Corbin McNeill, went to South Africa in January 2000, "to find out if this thing is for real." In February, Mr. Sproat said, "I led a team of about 10 people to South Africa to look at both the cost estimates and the technical issues, and based on that, we decided to become involved in the project."



Exelon's Ward Sproat: Still a year away from making a decision.



Philadelphia Electric Company

Peach Bottom 1 (at left) a 40-MW prototype high-temperature reactor, which operated successfully from 1966 to 1974. It was built by General Atomics and operated by the Philadelphia Electric Company, predecessor of Exelon.

Unfortunately, Exelon's strategy is not based simply on producing power cleanly and cheaply for the nation's future electricity grid, but on being "competitive" in a global market. A main reason for choosing the PBMR—in addition to its safety—is that the small units can be quickly produced and fitted into a niche in the chaotic, deregulated market.

As Mr. Sproat explained it, "As we go into the competitive wholesale power markets, what you have developing are regional markets around the country. And your opportunities to enter those markets, where there is a supply-demand mismatch, are going to be relatively limited. A traditional nuclear plant could take anywhere between six to eight or nine years to build, and the deregulated marketplace is not going to wait that period of time for you to build a new plant. That supply-demand gap is going to get filled by some other competitor."

But what will be the long-term efficiency of that competitor's quick fix? The "market" doesn't care. In fact, in this view, the "market" and the new economics of deregulation rule out the conventional nuclear plants of 1,000 megawatts or more, which can produce power economically, efficiently, and safely, including new reactors of advanced design that remain on the drawing boards.

Less Is More

In explaining why Exelon is considering the small PBMRs, Mr. Sproat also implicitly demonstrated how deregulation is actually driving costs up. "A 1,000-megawatt light water reactor plant, if you drop it into a market, can have significant impact on the prices being set in that market, drive prices down to the point where nobody is able to recover the cost of their investment," he said. "So we think that the small, modular design gives us advantages in terms of being able to add capacity into the power markets on an incremental basis.

"Also, the time to market, once you decide you are going to build one of these things, including the licensing process, once you get the design certified, you might be able to put these things up in three to four years, which is very competitive in a wholesale power market. It's about the same time to market as the combined cycle gas turbine."

The AVR experimental pebble bed reactor in Jülich, Germany, came on line in 1967 and operated successfully for 22 years. It demonstrated many safety effects of the high-temperature reactor. One test with the AVR showed that in a total sudden shutdown, the plant cools down and the fuel remains intact.

It is expected that the PBMRs could produce electricity "with all-in costs for under 3 cents per kilowatt hour," said Mr. Sproat, "We believe that this would be very competitive in wholesale power markets with any other form of generation out there."

Exelon does not plan to manufacture or sell PBMRs here, but to build them for power production. According to Mr. Sproat, the South African company would mass produce and ship the plants to where they were being assembled.

But, it is too soon to tell if the PBMR will come to the United States, given the current power-broker-based chaos. "We're still a year away from really having enough information to make an informed decision about should we proceed, should we do more studies, or should we kill the idea," Sproat said. "By this time next year, we should have a pretty good idea."

—Marjorie Mazel Hecht

Pebble Bed Reactor

Continued from page 60

recuperator at about 140°C, and its temperature is lowered further to about 30°C in a water-cooled precooler.

The helium gas is then repressurized, and moves back to the heat exchanger to pick up heat before going back to the reactor core.

This direct-cycle helium turbine, with a highly efficient recuperator, simplifies the reactor operations, eliminating the need for heat exchangers and secondary cycles, which are required in conventional light water reactors.

The net thermal efficiency of the PBMR is 45 percent, compared to the 30 to 35 percent for conventional light water reactors. This is one of the main reasons that the PBMR is projected to produce electricity so cheaply.

The outlet temperature of 900° is far higher than that of conventional light water reactors (280° to 330°), which gives this type of reactor its name: high temperature reactor.

Safety Systems

The inherent and passive safety systems of the PBMR are designed to make it "meltdown proof." The physical characteristics of the reactor are such that it shuts itself down, without any additional safety systems, in any imaginable accident scenario. As in the GT-MHR operation, there is a self-stabilizing temperature effect: If the temperature of the reactor core should heat up, this slows down the neutron production, because of the large amount of U-238 in the fuel particles, which captures the neutrons without fissioning.

The spent fuel from the PBMR also has built-in safety features. Because it is encapsulated in several coatings, including silicon carbide, the radioactive fission products remaining in the spent fuel are fully contained within the fuel pellets, and can be relatively inexpensively stored.

—Marjorie Mazel Hecht

For Further Reading

"South Africa Plans to Mass Produce Pebble-Bed HTR Nuclear Reactors," by Jonathan Tennenbaum, *21st Century*," Spring 2000, pp. 20-26.

INTERVIEW WITH GUILHERME CAMARGO

How Brazil's Nuclear Association Defeated Greenpeace

Guilherme Camargo, the director of the Brazilian Nuclear Energy Association (ABEN), was interviewed on Oct. 20, 2000, by Jonathan Tennenbaum, the editor of the German-language magazine Fusion, *and a member of the Scientific Advisory Board of* 21st Century. *Tennenbaum was in Brazil to attend the ABEN technical congress, and to release a Portuguese edition of his book,* Nuclear Energy: A Feminine Science.

Question: It is an honor to interview the person who many say played the decisive role in the remarkable renaissance of the Brazilian nuclear program, which has recently been demonstrated to the world by the outstanding performance of the newly completed Angra 2 power station. Could you briefly introduce yourself?

I am a mechanical engineer. I have a special graduate degree in nuclear engineering from the Federal University of Rio de Janeiro. I started working in the nuclear sector in Brazil in 1976. My whole professional experience is in the nuclear sector. For the last 12 years, I've been dedicated to the Brazilian Nuclear Energy Association (ABEN). I was the President of ABEN from 1988 to 1990. I rebuilt the whole institution, which had been virtually abandoned.

ABEN is a very important institution in the nuclear sector in Brazil, and has major political significance in our country. I would say it is one of the most active nuclear associations in the world.

Our recent Overall Technical Congress—in which you took part—had more than 700 registered participants and about 100 university students. It was considered the biggest event of its kind by an official of the International Atomic Energy Agency, who delivered a presentation to the Congress.

Question: Many people had written off the future of nuclear energy in Brazil and other developing countries. It is inspiring, and also a bit embarrassing, coming from Germany, to see how you have succeeded in your fight to reverse the dismantling of the nuclear sector, and completed the Angra 2 plant, which was a key feature of the German-Brazilian nuclear agreement signed more than 20 years ago. Can you give some historical background to this process?

I chose to work in the nuclear area back in 1976, when I was in the last year of my mechanical engineering course. This was just one year after Brazil has signed the nuclear agreement with Germany. At that time, I was struggling

The Angra nuclear power site: The Brazilian Nuclear Association's campaign against Greenpeace made possible the completion of Angra 2 (foreground), and the go-head for Angra 3 (and 4).

Guilherme Camargo: "The real fight has nothing to do with technical issues; it is purely political. . . ."

with the usual existential questions of students. I had had some unsatisfying professional experiences before, and I wanted to do something creative in the engineering field. Then I read a story in the newspaper about the first Brazilian nuclear engineers who were trained in Germany, and I said, "Aha! This is what I want to do; this is my salvation in this crazy engineering field."

I was trained in Germany in two two-year periods, a total of four years. I worked directly in building power plants in Germany, and I can say that I've participated in the completion of five nuclear power plants: Grafenrheinfeld, Grohnde, and the Konvoi project, which includes three power plants.

Question: What was your position?

I worked for the German firm KWU. At that time KWU was a completely independent company. During the first period, 1979-1980, I was an on-the-job trainee. The second time, I was hired by KWU when the Brazilian program started to sink into political problems. In order to preserve the technical capability in Brazil, KWU hired, for a certain time, good Brazilian professionals whom it had trained. I came back in 1983-1984, and I was responsible for the area of mechanical components, especially the systems for dealing with nuclear waste in nuclear power plants.

I was a kind of senior engineer, working together with the group manager and in many issues directly with the department manager. In addition to many other things, I had the opportunity of participating in the preparation of a proposal for a turn-key nuclear power plant in Akkuyu in Turkey. Because of my international experience and language skills, and my overall knowledge of the department, I was the main technical coordinator for this proposal in my department. It was a big and very interesting study, which cost 10 million deutschemarks. Unfortunately, the project was not realized, because of financial problems in Turkey.

Then I came back to Brazil. This was the 1980s, the time of the debt crisis in Brazil, and the government was totally out of money. My company was also totally out of money, and, in addition, there was a terrible campaign conducted directly out of the U.S. State Department—we have strong evidence for this—against the German-Brazilian nuclear agreement.

The signal for the beginning of the campaign was the famous article in [the German weekly] *Der Spiegel,* titled "Die goldene Eier—der Deutsch-Brasilianische Kernenergie-Abkommen" [The Golden Egg: The German-Brazilian Nuclear Agreement]. This was a terrible report, and it generated a Parliamentary Investigation Commission in Brazil. At that time, there was a military government in Brazil, and this issue gave a very unique possibility for opposition politicians to make charges against the military government, because the whole thing was considered to be a "technical issue," not a political issue.

And the fact is, that the nuclear programs in Brazil were totally destroyed. In 1993—I am shortening the story—Greenpeace was founded in Brazil. They opened offices in Rio and in São Paulo, and in that year there was a terrible defamatory campaign in all newspapers, and the whole media, to finish off the nuclear program. No politician would dare to talk to us about nuclear energy. They stayed away from us, for fear of being seen with people who had been portrayed as insane killers. There was a very important additional factor that should be mentioned, which was the radiological incident in Goiania in 1987 [where discarded medical equipment exposed unknowing local residents to radiation], which enhanced the entire anti-nuclear campaign in Brazil. It was a terrible situation. . . .

Question: Although that accident had nothing to do with nuclear energy. . . .

Yes, but you know that if an insignificant leak develops in a power plant in Japan, then reporters will call us to ask if such a thing could happen in the Angra plant here.

In addition, we had a very bad startup of the Angra 1 plant, full of technical problems. In my personal opinion, Angra 1 was based on a bad agreement with Westinghouse, because the design was already obsolete in terms of efficiency—not in terms of safety, but in terms of efficiency. The Westinghouse design used for Angra I was at that time not the state-of-the-art. So it had enormous problems.

Also, at the beginning of the 1990s, the U.S. State Department blocked the supply of the fuel elements for Angra 1, which Westinghouse had designed. This was a unilateral breaking of purchasing contracts and international agreements. At that time the Brazilian utility involved, decided to improvise, to use adapted Siemens nuclear fuel elements, which are slightly different from the original

ones, and we had some problems with some small leakages in the fuel rods.

So, because of technical problems, political pressures, and a total lack of political support, the plant remained closed for almost one year. That was the time when the Greenies started to call this a "firefly plant," because it was turned on and off so frequently!

That was the situation. There were extremely aggressive editorials against nuclear energy, for instance, in important newspapers such as *Gazeta Mercantil,* which is comparable to the U.S. *Wall Street Journal*—a journal for businessmen. The whole nuclear sector was in despair and had no idea what to do.

So, I and some colleagues of ABEN presented to the CEOs of the main nuclear companies and institutions a strategic plan for how to reverse this terrible situation in a short time. That strategy was totally unorthodox and unusual. Nobody had done this before, but we had very special conditions. We hired very good professional press agents, and, through them, we finally made contact with the big guys in the media, the top publishers and editors of the newspapers, who were friends with these press agents.

At first, we went to them and told them that nuclear energy is not so bad, that the cheapest solution was to finish Angra 2, and that there was no other good option; otherwise the country would go into an energy disaster. And, at the time, Angra 1 was functioning very well.

But press people said, "So what? This is no news, my friend." You know, there is a saying among journalists in Brazil: "If a dog bites a girl, this is not news. But it would be front page news, if the girl bites the dog!"

So I started thinking about that, and at that moment I took notice, through the U.S. weekly *Executive Intelligence Review,* about the Icelandic journalist Magnus Gudmundsson. He had made movies about Greenpeace, presenting very strong criticisms and evidence, which had a huge impact in the Scandinavian countries. He was mainly focussed on fishing and whaling issues, but he had collected a set of evidence, and he was very aggressive.

So, we got directly in contact with Gudmundsson in Reykjavik, and we got all his films. And when I took a look at those videos, I was very excited. I said: "Now we have something. Now we have the girl who has bitten the dog!" The next day, I went to São Paulo with my press agent, to the leading magazine, *Veja,* which is equivalent to *Der Spiegel* in Germany, and I talked to the general editor. I said to him: "Okay, my friend. You said that if a nuclear power plant has a very good performance, this is not news. So you would like bad news. You are making propaganda for this corrupt organization called Greenpeace, for this bunch of criminals and liars. What if I show you some consistent evidence of that? Would that be news for you?"

This was during a lunch. The editor was very shocked and he honestly said: "If you have real evidence about that, certainly it is big news. Show me." I gave him the films. He called me the next day and said, "This is fantastic! I want to meet this fellow [Gudmundsson]."

We quickly arranged a visit of Gudmundsson to Brazil, a presentation by him to the National Congress, and a meeting for him with Gilberto Mestrinho, who was the governor of Amazonas and a kind of Brazilian anti-green leader. When Gudmundsson arrived in Rio, an explosive interview with him had already been published, titled something like "The Rotten Truth about the Greenies," and telling the whole story about the revelations of former Greenpeace leader McTaggart, secret accounts, manipulation of Caribbean countries [around whaling issues], and so on.

Gudmundsson is very convincing because he is a journalist. This interview had been done by telephone, in such a way, that when Gudmundsson arrived in Brazil, the magazine was already on newsstands. We arranged a press conference in a hotel the same day he came, and there were about 30 journalists from the mass media in Brazil present.

That happened in May 1994. So we started out, in this campaign of communication with the media, by attacking our enemies. The discussion had nothing to do with nuclear energy per se. For example, I participated in a live television debate together with three persons

ENTREVISTA: MAGNUS GUDMUNDSSON

Os podres dos verdes

O autor de três filmes com ataques contra o Greenpeace diz que a maior entidade ecológica do mundo tem contas secretas, é corrupta e mentirosa

ANDRE PETRY

O islandês Magnus Gudmundsson, 40 anos, já plantou muitas árvores na vida. Na juventude, fazia excursões a uma região da Islândia, país situado no extremo do Hemisfério Norte, só para plantá-las. "Devido ao frio, temos poucas árvores. Mas, se plantadas, elas sobrevivem. Na região a que eu ia hoje há uma pequena floresta", diz. O jovem ecologista tornou-se o inimigo número 1 do Greenpeace, a barulhenta organização ecológica com 5 milhões de filiados em trinta países. Jornalista, Gudmundsson foi escalado em 1984 para cobrir uma eleição na Groenlândia. Lá, viu o estrago que uma campanha do Greenpeace estava provocando nos esquimós com a proibição da caça da foca. Tomou um empréstimo no banco e produziu um documentário, em 1989, denunciando a entidade. "A intenção era fazer só um. Mas o Greenpeace passou a me atacar onde pode. Agora, estou empenhado em mostrar que eles não produzem consciência ecológica. Produzem manipulação e histeria", afirma.

Em 1993, fez outros dois, um deles agraciado como o melhor documentário do ano na Escandinávia

"O Greenpeace tem pelo menos dezessete contas bancárias secretas. Nelas, há 70 milhões de dólares escondidos"

poder, uma enorme influência na mídia do mundo inteiro e recolhe 200 milhões de dólares por ano. David McTaggart, que presidiu o Greenpeace por doze anos, é o dono da entidade. A marca Greenpeace International está registrada no nome dele na Câmara de Comércio de Amsterdã, na Holanda.

VEJA — *É uma empresa privada?*

GUDMUNDSSON — Sim. Quem quiser fundar um escritório do Greenpeace tem de pagar ao senhor McTaggart pelo uso da marca. Funciona como um sistema de franquia. O Greenpeace é o McDonald's da ecologia mundial. Cada escritório no mundo é obrigado a mandar um mínimo de dinheiro por ano para Amsterdã, a sede do Greenpeace International. Oficialmente, deve mandar 24% do que arrecada. Também existe uma cota mínima de contribuição. Só que é tão alta que há escritórios, como o da própria Holanda, que chegam a mandar até 60% do que recolhem. Quem não faz dinheiro cai fora. Na Dinamarca, eles demitiram o pessoal todo. Na Austrália também.

VEJA — *Não é um meio lícito de*

The explosive interview with Icelandic journalist Magnus Gudmundsson in Veja, *May 4, 1994, which documented the lies and shady financial deals of Greenpeace.*

from Greenpeace and other NGOs [non-governmental organizations], where the audience could ask questions.

One fellow got up and said, "The nuclear sector has lots of problems; it is dangerous and poisonous." But I said to the moderator, "I don't understand; are we here to discuss nuclear energy or about NGOs?" And the moderator said, "You are right; no discussion about nuclear here, just about Greenpeace, just Greenpeace."

So we spent almost eight months hitting Greenpeace in the liver very carefully, and very sharply. Also, after that event, we had access to internal information from Greenpeace Brazil.

Question: What was Greenpeace then doing in Brazil?

The main focus of the startup of Greenpeace in Brazil was a sharp, deadly attack against the nuclear sector. Their initial aim was to collect 500,000 signatures for a declaration calling for shutting down the Angra 1 plant, and immediate stopping construction of Angra 2. We knew that. The President of Brazil at that time was Itamar Franco, who was, in fact, very anti-nuclear. And Itamar had been the head of the Parliamentary Investigation Commission on the German-Brazilian nuclear agreement in the beginning of the 1980s, when he was a Senator.

So, I said, we have to wipe out these guys. It was like a Western movie, a kind of "Gunfight at OK Corral." You kill or you die. And we destroyed these guys. The Greenpeace anti-nuclear manifesto was a disastrous failure. The President, who at the beginning of his term had received the whole Greenpeace Board of Directors, refused to receive the manifesto after the news in the press.

Instead of having 500,000 signatures, they got only 30,000, and of these 30,000, 90 percent were collected among teenagers, mainly high school students 15 to 16 years old! I would actually estimate that 29,000 of these 30,000 signatures were collected from pupils in Brazilian schools, mainly in Rio and São Paolo. We proved that in one very large English course alone, which had several branches throughout the country, the teachers and board of directors collected 12,000 signatures from the students. So, when Greenpeace went to the Congress to present this manifesto—because the President had refused to receive it—they went to the Chamber of Representatives, and took an exhibition of drawings of children against nuclear energy. But on the same day, we presented to the deputies the evidence, from investigating the identities of the signatures, that Greenpeace had collected signatures from high school students. When the deputies saw our evidence, they abandoned Greenpeace, and the exhibition of drawings was removed the next day. Greenpeace was banned from the Congress.

In the following days, the president of Greenpeace Brazil was fired, and in the next two months, Greenpeace declared to the press that its income had dropped to 10 percent of the preceding year, even less than 10 percent.

So, after a short time, Greenpeace totally abandoned having an anti-nuclear campaign! I think Brazil is the only nation in the world where Greenpeace is not running an anti-nuclear campaign. They have totally given up attacking us; they don't talk about nuclear energy in Brazil.

During this period, my colleagues often asked me: "What are you doing? Are you here to attack Greenpeace or to defend the nuclear cause?" I said to them, very upset about this lack of understanding: "Oh, don't you think it is the same thing?"

"So we spent almost eight months hitting Greenpeace in the liver very carefully, and very sharply."

And then, these people, our friends, the scientists and engineers, started to realize what was really going on; that there was a fight, a harsh combat, a war, and that war must be taken on, and that there was no other way: that we had to defeat the enemy in order to succeed in our aims. They understood that we should not go into silly, orchestrated anti-nuclear events, arguing about the safety of nuclear power plants, saying that the probability of an accident is 10 to the minus so-and-so—this kind of nonsense that all nuclear guys in the whole world usually use as strategy.

And the whole nuclear sector in Brazil—because they are not idiots, they just needed somebody to wake them up from this psychotic trance—woke up to the real fight. The real fight has nothing to do with technical issues; it is purely political, and mainly emotional and psychological warfare. As a matter of fact, we used the same tactics that the anti-nuclear people used against us.

The collateral effect of this anti-Greenpeace campaign, after we had destroyed them totally, was that we got enormous credit in the eyes of the media. The press, the journalists, started to say: "these people are telling the truth, they deserve our attention. They brought up a very dangerous issue, and they were right, so at least we must hear what they say."

Question: Was this success based only on Gudmundsson and his evidence from Iceland, or did you have evidence about how Greenpeace was operating in Brazil? In Germany there is an aura of legitimacy built up around Greenpeace.

I must say very honestly, that I have been a reader of *Executive Intelligence Review* since 1988, when I started in the presidency of ABEN, and I was in contact with the EIR representative in Brazil, Lorenzo Carrasco. I benefitted enormously from the strategic information we got from EIR, and from the more theoretical issues in *21st Century Science and Technology*. We are institutional subscribers to both magazines. And basically we got the first reports on Greenpeace from those sources.

Of course we started to make an enormous research effort by ourselves. But the hints from EIR were decisive. In fact, we wouldn't have known about Gudmundsson if I were not a reader of EIR.

EIR and *21st Century* present the much larger, philosophical, historical, and strategic perspective about the whole deployment of the NGOs against developing nations, and who is really behind it. There is the book [in German] of EIR's Ralf Schauerhammer, *Sackgasse Ökostatt* [The Dead-end Eco-state]. which I read, and *21st Century*'s *The Holes in the Ozone Scare* by Rogelio Maduro. I also read other books which are mentioned in those publications, for example, the two books of Dixy Lee Ray.

So, we had an enormous amount of information before getting into this fight. And we learned very quickly how to deal with the press. For us engineers and scientists to deal with the press requires professional help. Up to now, it had

Sample headlines from the Brazilian press on the crimes of Greenpeace and other NGOs.

been almost impossible to work without an excellent press agent. . . .

Question: In Germany the nuclear industry also has press agents, but has failed miserably. . . .

But these are not press agents; these are what we call in Brazil "white plates." You know, official cars in Brazil have white license plates, so such press agents are white plate journalists. They did not really work in the press, and were not considered to be colleagues by the real journalists.

Question: But the essential aspect about Greenpeace, which you mentioned earlier, is the relationship between its activity and the U.S. State Department move against the German-Brazilian nuclear deal. In Brazil, you were able to convince people that the activity of Greenpeace and other environmentalist NGOs was directed against the national sovereignty of Brazil, that it was a kind of act of war. . . .

Sure.

Question: And you could prove this in debates with Greenpeace and the environmentalist NGOs?

We could prove many things; for instance, that England's Prince Charles is a member of the high-level committee of Greenpeace, as Prince Philip is the owner of the World Wildlife Fund [WWF]—so both institutions are closely tied together. We could demonstrate that Greenpeace has received donations from many high-level groups and financial foundations. We could prove that there were strong accusations of corruption inside Greenpeace. Greenpeace could not respond, and could not deny this. Even in court cases in Scandinavia, Greenpeace had lost every lawsuit.

So, we had all the information about those connections. But we extended the debate beyond Greenpeace, to the whole array of NGOs and their impact in Brazil.

When Fernando Henrique Cardoso took charge of the Presidency of Brazil, he said that the NGOs, in fact, constituted "*Neo*-Governmental Organizations." I wrote a strategic article in *O Estado de São Paulo,* one of the country's most important newspapers, stating the truth about the NGOs and the whole grand strategy about using them to eliminate sovereignty of the country.

This article was followed by many articles by conservatives in Brazil. For example, by Miguel Reale, a famous attorney and law professor in Brazil, and former President of the University of São Paulo. He wrote an article restating my arguments. Then *O Estado de São Paulo* published a Sunday edition with a front-page story saying that the NGOs were manipulating hundreds of millions of dollars in Brazil, without any control by the Central Bank, without any control whatsoever, and with a total permission by the governmental authorities, and that this had created a terrible situation for the development of the country. So, I think the Federal Government and the President reconsidered their initial position, and, in fact, have changed it.

Question: When were these articles published?

They were mainly published in the year of the great war with Greenpeace, which was 1994, the year that Fernando Henrique Cardoso was elected and took office. And, as I said, we rapidly extended the range of the debate beyond Greenpeace, which was already dead; we extended it to the entire NGO and environmental movement. We looked for other possible allies in this war, such as, for example, the timber industry in the Amazon region, the paper industry, and other areas which were starting to be attacked by the environmental movement.

Question: Were these international environmental groups?

In fact, in Brazil the local groups are almost 100 percent financed by international groups, such as WWF, which is today the most powerful NGO in Brazil. This is not only from the environmental point of view—WWF is trying to act as a kind of parallel government in Brazil. We were the first to publicly denounce this WWF campaign and we are preparing ourselves for a much greater and more dangerous fight.

Question: Getting back to Angra 2: You said that you had an enormous credibil-

ity after the victory against Greenpeace. What happened next?

The politicians started to say to us: "Very good, my boys, you did a great job. Now I can defend you. Now it is very easy to fight for Angra 2. We think you did a great job, so we are in a position to fight for budgets and to go public." And that started very naturally.

We adopted an additional strategy, to turn the question of Angra 2 into a regional question, engaging the whole state of Rio de Janeiro. Because in this state, as in Bavaria in Germany, there are lots of nuclear institutions; 90 percent of Brazil's nuclear infrastructure is in Rio de Janeiro. So the parliamentarians of all parties, from the extreme left to the extreme right, signed a manifesto in favor of completion of Angra 2.

For the first time, in 1995, Congress approved an adequate budget for Angra 2, more than $300 million, and in the same year, the government decided to quickly contract a consortium of construction companies, opening the critical path for completion of the plant. With the contractual arrangements of seven large Brazilian construction companies, the operation flowed as I had seen it happen in Germany in the 1970s, and the beginning of 1980s. We finished this plant in five years, which was the minimum time prescribed by Siemens-KWU. In Germany, in a similar situation, they could not have finished in a shorter time.

So, we completed the plant within the time and cost framework we had promised. And that was a big concern, because we had no alternative. It was like the last bullet: you can't miss the target. If we had failed in the construction of this plant, it would have meant the end of the nuclear sector. And, you know, the construction of a nuclear plant is the most complicated engineering task. Perhaps with the exception of some great aerospace projects, there is no other engineering project that is so complex from the managerial and technical point of view.

This was the largest size power plant, 1,300 megawatts—now the French have a 1,400 MW. But our plant has outstanding performance. In the first 100 percent power run, it exceeded the nominal power and produced 1,370 megawatts. We got the extra 70 MW as a kind of side gift, like the "freebees" you get in conferences or something like that!


Um agente de segurança do Consulado da França no Rio aponta a arma para dois manifestantes do Greenpeace

From the front page of Brazil's Jornal do Brasil, *Sept. 7, 1995: A security guard at the French Consulate in Rio points a gun at Greenpeace activists who were blocking the doorway of the Consulate, in protest of the French atomic tests in 1995.*

Question: What was the situation of the nuclear sector in Brazil, when the German-Brazilian nuclear deal started to stagnate, 20 years ago?

Everything had been stopped in the nuclear program. The fuel cycle was paralyzed. Research and development activities were stagnating. Everything was paralyzed. So Angra 2 is just the most visible benefit of our victory. In fact, the whole fuel cycle has been developed. This was a very important effect.

ABEN has strongly worked to integrate the so-called autonomous program and the international program, the one that developed through the German-Brazilian nuclear agreement. The opposition to nuclear energy had followed a very typical strategy, to artificially stimulate a kind of divergence between these two programs. When we started out, the two programs were fighting publicly. This was not new, because before that there was the fight between the nuclear people and the hydroelectric people.

Now we have to teach the authorities, how to re-manage an energy sector in a country like Brazil. First: stop fighting! We need all the energy sources that are viable. Of course, we are not talking about solar, wind, or such crazy things. We need hydro plants, we need gas plants, we need coal plants—and we need nuclear.

So now every authority in the country has assimilated this, and the nuclear sector has stopped its internal fighting. The main fruit of this integration is the new ultracentrifuge enrichment facility that is being build in Resende, which uses the domestic technology developed by the Brazilian Navy. It will be commercialized by INB, the successor company to Nuclebrás, which was the main agent of the German-Brazilian agreement.

Meanwhile, in research and development, especially in the application of radiation and radioisotopes, there has been enormous progress. Nuclear medicine is developing in Brazil at perhaps the fastest rate in the whole world. Everything is based on domestic technology. Our magazine *Brazil Nuclear,* which goes to opinion-makers throughout the country, received a very interesting letter from the chief doctor of the nuclear medicine department in the most famous hospital in Brazil, the hospital of the University of São Paulo. She wrote: "Thank you very much for your nice work and your nice magazine, because by teaching the public about those precious achievements of nuclear science, my patients no longer are afraid of getting nuclear medicine diagnosis, which was a terrible problem I had to face."

For us, this is the best recognition that we can have from this whole work.

Question: What about Angra 3?

Well, as I think you have seen from all those statements in our congress by the Brazilian nuclear community and public authorities: We will build it for sure—with the Germans, without the Germans, with the French, with the Japanese, or without them. And if there is nobody who wants to participate in this great business, then we will build it by our own means. We, in ABEN, have no doubt about this. We are preparing ourselves for this next step.

The government has no other option, because we have an enormous energy crisis and no one could afford the decision of wasting away almost $2 billion of invest-

ments already made in the plant. We think that this situation is now being approached by the government in the right manner and with the necessary political will. It has to be faced. And Angra 3 is the first option, no matter what appears in the press.

And here is a special message for the Greens, this small group of demagogic politicians in Germany and in Brazil: No matter what you say, no matter what unilateral conditions you are trying to impose on our nation, you have lost this battle. Angra 3 is already a reality. In fact, in one of our recent magazines we made a photo-montage of the site of the Angra central nuclear power station, with Angra 3 totally completed on the right place. This picture itself has had a very strong impact on the authorities.

And the most interesting thing in this photo-montage, is that you can see clearly that there is enough space for a fourth nuclear power plant at the same site! It is normal to do that in Japan or in France; a site should normally be developed for at least four power plants. I think that the fourth power plant is already also guaranteed. I have no doubts about that.

Question: That is a good message for German Chancellor Schröder. . . .

I used to say that Social Democrats in Germany are not made today the way they were in past times. I am from the generation of young Brazilians who admired the work of Helmut Schmidt, and for me he was a good and honest politician, the kind of Social Democrat the world needs now, not like the present ones. I hope Mr. Schröder will return to the original base of the Social Democratic Party in Germany and take some lessons from Helmut Schmidt, who signed the German-Brazilian nuclear agreement.

Prince Philip's WWF Sues LaRouche Affiliate in Brazil

The Brazilian branch of the World Wide Fund for Nature (WWF), the international environmentalist organization founded by Britain's Prince Philip and former Nazi Party member Prince Bernhard of The Netherlands, filed a slander suit in a Rio de Janeiro court on March 5 against the Ibero-American Solidarity Movement (MSIA) of Brazil.

The successful effort to defeat Greenpeace, reported here, is an included part of the reason their highnesses are so upset.

Earlier, on Jan. 19, WWF-Brazil had obtained a prior restraining order against the Brazilian political organization, which is part of the international political movement associated with U.S. 2004 presidential candidate Lyndon H. LaRouche, Jr.

The restraining order included a court-ordered search and seizure of MSIA publications, which WWF-Brazil found offensive to its "honor." This grossly unconstitutional prior restraining order was obtained by WWF-Brazil, despite the fact that it at no point presented evidence refuting the truthfulness of the MSIA publications.

The content of the March 5 slander suit has not yet been made available to the MSIA's lawyers.

On Jan. 27, in response to the original restraining order, EIR founder Lyndon LaRouche issued a report analyzing what was behind the WWF attack on him and his associates, entitled "Look At What Happened in Brazil." LaRouche explained there, that the central issue in the Brazil incident was the British Monarchy's ongoing attacks against him, personally, and what he stands for as an international alternative to their genocidal policies. LaRouche noted: "The personal attack on me, shows that WWF's targetting of Brazil expresses a much broader, global intention."

"Protect yourself against the false environmentalists!" This is an ad for the Portuguese-language book published in Brazil by EIR, titled Green Mafia: Environmentalism in the Service of World Government.

That intention includes deploying such forces as the British-French financial oligarch, Teddy Goldsmith, the radical environmentalist organizer of the recent Pôrto Alegre, Brazil, gathering of global Jacobin movements, to stop any promotion of industrialization, either by sovereign nation-states or by nationalist forces within those countries.

Although the Brazilian government of President Fernando Henrique Cardoso has itself shared much of the outlook and policies of the WWF, LaRouche noted that the Brazilian government is also in mortal danger from the British-sponsored offensive:

"If Brazil's government were toppled by aid of WWF's activity, then all of continental Europe, not excluding 'Teddy' Goldsmith's France, in addition to Brazil itself, would be obviously the next target on the list for destruction. If Europe, too, goes under as a continuation of the chain-reaction touched off in Brazil, the fate of the rest of the planet is menaced accordingly."

Much to the dismay of the British Monarchy, LaRouche's MSIA has become a national rallying point in Brazil for opposition to such policies. As LaRouche noted in his Jan. 27 document, the MSIA's publications "have radiated throughout many of the leading channels of Brazil's influential state, scientific, and other strata, to the point, that many of those circles have reached the conclusion that WWF's policies are both largely false as to fact, and represent a clear and present threat to the welfare of Brazil as a sovereign nation."

A COORDINATED WALL ST. ASSAULT

Who Killed U.S. Nuclear Power?

by Marsha Freeman

The U.S. Atomic Energy Commission (AEC) made a projection in 1962, that by the year 1980, 40 gigawatts of nuclear-generated electric capacity would be on line in this country (the equivalent of about 40 plants of 1,000 megawatts capacity each). Two years later, amid the optimism generated by President John F. Kennedy's Apollo program to land a man on the Moon, the AEC revised its projections upward, to 75 GW of nuclear capacity by 1980.

By 1967, through the momentum of the lunar landing program and its high-technology economic expansion, the AEC again upped its projections, this time to 145 GW of nuclear capacity by the year 1980. Engineers in the industry, looking farther ahead, expected 2,000 GW nuclear by the year 2000.

Now, in 2001, there are only 103 nuclear plants in operation in the United States. More than that number have been cancelled. The collapse in orders, and cancellations, have left the U.S. nuclear industry in such a state of contraction, that today it could not even build a new nuclear reactor, were one to be ordered. The pressure vessel would have to be imported, because there is no U.S. firm capable of fabricating one.

There are many myths about who killed nuclear power in this country. Blame is put on the accident at Three Mile Island in 1979, which certainly added to the attacks on the industry, but was not a decisive factor. Blame is put on the American public, which supposedly became anti-nuclear (although, except for a small vocal minority, this has never been the case). The claim is made that nuclear is inherently just too expensive to use, but, in fact, it was a coordinated assault by Wall Street and its foot soldiers in the environmentalist movement that drove the costs up.

If we do not understand how we got to where we are, we will never be able to change the situation.

Soon after President John F. Kennedy was assassinated in 1963, the international financial and oligarchical interests who despised his pro-nuclear, pro-space, and economic growth policies, moved in to bury them.

Figure 1
OPERATING U.S. NUCLEAR PLANTS

The 103 nuclear power plants operating today in the United States produce the most reliable, and most efficient 20 percent of the electric power grid. Total capacity is 96.245 GW.

Source: Nuclear Energy Institute

The Paradigm Shift

The founding of the Club of Rome in 1969, by co-thinkers of European royal families and their toadies in the United States, helped launch a propaganda campaign to convince policymakers and citizens that the world has too many people. Volumes of reports from the Club of Rome and affiliated think tanks opined that science and technology could not alleviate the alleged "overpopulation," and that, in any case, that technology has many "negative" consequences, such as damaging the environment.

The passage of the National Environmental Policy Act the same year, 1969, made the criterion of how economic projects would affect plants, insects, and animals more important than the impact those projects would have on the economic health of human beings.

The 1973 Middle East War, and the ensuing manipulated "oil crisis," threw energy policy and planning into turmoil. Overnight, oil prices quadrupled, and coal—until then the mainstay of electricity generation—also rose in price. Under his Project Independence program, to increase the exploitation of domestic energy supplies, President Richard Nixon called for the building of 1,000 nuclear reactors by the year 2000. But soon, Nixon was out of office, and the anti-nuclear moles inside his Administration had already been planning the demise of nuclear energy.

Already in 1971, within days of becoming the head of the Atomic Energy Commission, James Rodney Schlesinger, who had come to Washington from the RAND Corporation, overturned a critical AEC decision. He allowed the Natural Resources Defense Council, which had been formed in 1970 by representatives of top Wall Street law firms, to "intervene" via lawsuits to stop construction of the Calvert Cliffs nuclear

plant in southern Maryland. The reason given was that the plant would damage the "environment." This action laid the basis for two decades of legal maneuvering by environmentalists-in-three-piece-suits to keep utilities tied up in court for years, with bogus environmental and safety concerns, making it impossible for many plants to ever be completed.

With the election of Jimmy Carter as President in 1976, anti-nuclear, pro-environmental policy was brought right into the White House. In preparation for the new Democratic Administration, the New York Council on Foreign Relations, a spinoff of the London's Royal Institute of International Affairs, produced its *Project 1980s* report, which called specifically for the "controlled disintegration" of the U.S. economy.

The Rockefeller-funded Trilateral Commission, whose membership dominated the Carter Administration, adopted this Project 1980s perspective as its own. Central to their theme of controlled disintegration was the halt of new energy technologies on the horizon, such as advanced nuclear fission and fusion energy. In their place, they promoted the institutionalization of "conservation," and small-is-beautiful "alternative" energy, based on inefficient and expensive wind, solar, and biomass—technologies which had virtually disappeared after the Industrial Revolution. Billions of dollars in federal subsidies were poured into these 19th century throwbacks, to try to make them economically palatable to an otherwise highly skeptical public.

The new Department of Energy, which replaced the Atomic Energy Commission—an act that in itself demonstrated the shift in policy—again came under the control of James Schlesinger. While Schlesinger was making speeches about how nuclear energy was not "cost effective," the Department of Energy showed its anti-technology stripes by actively promoting and participating in "Sun Day" festivities.

The first step toward deregulating the electric utilities took place, under the Carter Administration, through a 1978 Act that gave small, "renewable" energy producers access to the electric grid, and forced utility companies to buy their outrageously priced power.

A march on Washington of 65,000 anti-nuclear demonstrators on May 6, 1979, used the March 1979 incident at Three Mile Island to call for the shutdown of the nation's then-operating 68 nuclear reactors. This Jacobin mob was the street-level creature spawned by the Council on Foreign Relations and Wall Street's largest non-profit foundations, in the name of "protecting the environment." The demonstration further fueled the efforts in the White House and Congress to enact rules and regulations to sabotage the completion of nuclear plants.

The machinations of the anti-nukes also increased the pressure on the Nuclear Regulatory Commission to institute irrational new rules and regulations, which, on one occasion, resulted in 13 power plants being shut down at the same time, for "safety" inspections. Billions of dollars were spent by nuclear utilities to retrofit plants for increased safety, much of which retrofitting was known by many in the industry to be unnecessary. At the same time, the nuclear utilities were bending over backwards to "listen" to and answer the "concerns" of the anti-nukes, in the hope that this process would instill some rationality into the situation.

It was during the Carter administration, that the predecessor to *21st Century,* the Fusion Energy Foundation's *Fusion* magazine, and the associated political movement of Lyndon LaRouche, took the lead in exposing the Trilateral Commission/Council on Foreign Relations/Wall St. role in fostering and funding the environmentalist movement and its terrorist spinoffs.

In the closing days of the Carter Administration, Lyndon LaRouche, preparing to run for President in the 1980 election, released a report titled "America Must Go Nuclear." In the introduction, LaRouche stated: "On my first day in office, I shall deliver to the Congress a comprehensive energy policy. This legislation will repeal the worst features of the Environmental Protection Act, permitting work to be completed on the approximately 120 nuclear energy plants presently stalled in various phases of construction. It will also provide for

Washington Public Power Suppy System

Wall Street's high finance rates killed 5,000 megawatts of nuclear power capacity—four plants—in 1981, midway in construction in the Washington state WPPSS Project, shown here. If the four nuclear plants planned by WPPSS had been completed, the Pacific Northwest would not have an energy crisis today.

Figure 2
THE COLLAPSE OF NUCLEAR REACTOR ORDERS AFTER THE 1973 OIL HOAX

It is a myth that the accident at Three Mile Island in 1979 caused the demise of the nuclear industry. As can be seen here, the number of new nuclear plants ordered reached a high of 35 in 1972, and then collapsed to zero after the "oil crisis" of 1973.

Source: Atomic Industrial Forum

the addition of 1,000 gigawatts of nuclear energy by 2000 A.D."

President Reagan, who was touted as the first pro-nuclear President in 20 years when elected in 1980, did not even understand the systemic policy changes that would be required to resurrect the nuclear industry.

The Economic Assault

Although the 1974 "oil crisis" led to a renewed interest in nuclear, as evidenced by the number of plants ordered immediately afterwards, a well calculated act by Federal Reserve Chairman, Paul Volcker, one of the many Trilateral Commission agents in the Carter team, dashed the attempts to go nuclear.

Over the Columbus Day weekend in 1979, Volcker raised interest rates in the United States into the double digits. This move had an immediate impact on two consumer goods sectors that rely heavily on credit—automobile purchases, and home mortgages—but the effect on the electric utility industry was more dramatic, and more far reaching.

The idea that the nation did not have to build more power plants, especially nuclear plants, because the economy and energy consumption had fallen, was a self-fulfilling prophecy. When energy prices skyrocketed in the mid-1970s, industries and consumers cut back, to buy what energy they could afford. Traditional 1960s growth rates for electricity demand of 7 percent per year, shrank to 2 to 3 percent per year, and projections for the future decade, based on the forecast of an extended economic recession, were in the 1 to 2 percent range. Once energy supply is made expensive, it can be expected that consumption will decline. Historically, inexpensive energy has fueled increased demand, not vice versa.

Suddenly, after the oil shock, with demand falling, the nuclear plants that were in the pipeline were seen as "over capacity," an unnecessary "surplus" of power that no one should have to pay for. It was not the Three Mile Island incident in 1979 that started the rush to cancel nuclear plants. Between 1973 and 1979, more than 40 had already been cancelled. And by 1979, the projections for nuclear power by the Department of Energy were slashed to 150 GW by the year 2000. Orders for new nuclear plants disappeared, as seen in Figure 2.

By 1981, electric utilities, which operate the most capital-intensive industry in the nation, were paying 17 percent interest on loans for the construction of power plants. This might have been a bearable escalation in cost, were it not for the fact that the construction time for nuclear power plants was being stretched out from eight years to up to twenty—thanks to anti-nuclear "intervenors" who made a profession out of tying up utilities in court. No company, no matter how solvent, could pay such

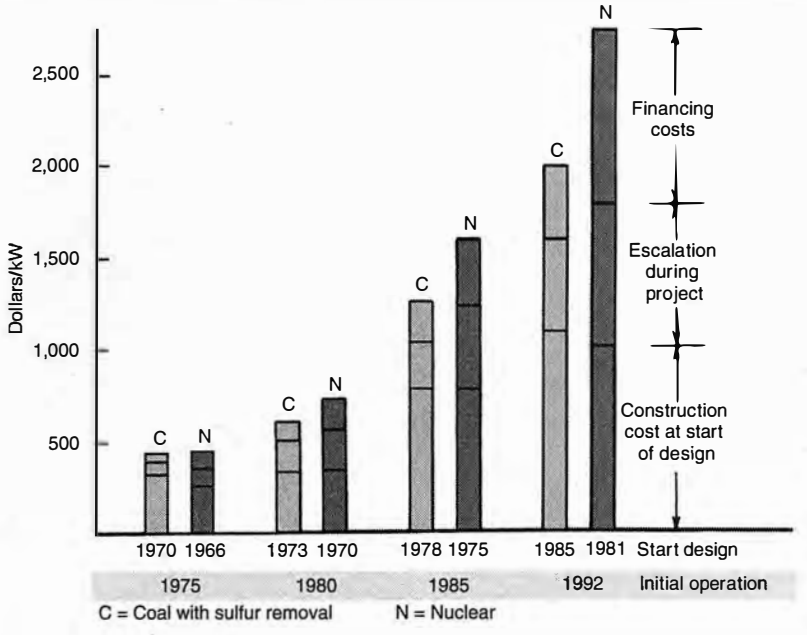


Figure 3
ENVIRONMENTAL DELAYS AND USURIOUS FINANCE CHARGES SENT THE COST OF NUCLEAR POWER ZOOMING UPWARD

Nuclear power is not intrinsically expensive. What drove nuclear plant costs up were environmentalist delays (caused by anti-nuclear "intervenors" and the high interest financing rates—both perpetrated by those who wanted to kill nuclear power, and who now complain that nuclear costs too much. Shown here, in dollars per kilowatt are the rising costs of financing, environmentalist delays, and construction materials increases for nuclear (N) and the rising costs for comparable coal-fired plants (C) with sulfur removal.

Source: Electric Power Research Institute

PROJECTED VS. ACTUAL COST OF SELECTED NUCLEAR POWER PLANTS
(in billions of dollars)

Unit	Megawatts	Initial cost estimate	Actual cost
Millstone III (Massachusetts and Connecticut)	1,150	.400	3.82
Limerick 1 (Pennsylvania)	1,055	.344	3.80
Wolf Creek (Kansas)	1,055	1.03	2.93
Susquehanna 1 (Pennsylvania)	1,050	.665	2.05
Susquehanna II (Pennsylvania)	1,050	.720	2.05

Nuclear power plants that should have cost between $500 million and $1 billion, had their final costs escalate up to 10 times that amount, over the course of construction, thanks to unreasonable regulations by the Nuclear Regulatory Commission, and the stretch-out of schedules over bogus "environmental and safety" concerns. Note that GE and other U.S. firms currently build 1,000 MW and larger nuclear units in Japan, Korea, and Taiwan in 4 to 5 years.

Source: Public Utility Commissions in the respective states

interest rates, for two decades, while waiting to recoup the cost from the generation of power.

In March 1981, Wall Street's Merrill Lynch issued a report recommending the cancellation of 18 nuclear plants, because of the financing costs. Utility bond sales were cancelled by financial houses. Six months later, Boston Edison's Pilgrim-2 plant was cancelled, as the cost had escalated from $400 million to $4 billion, simply because of the schedule stretch-out and high interest rates.

In August 1981, the Washington Public Power Supply System (WPPSS) in Washington state, had its credit rating cut by Moody's Investors Service, and bond underwriters demanded that both the interest *and principal* on the loans had to be repaid before the nuclear plants generated any electricity or revenues. Of the five planned reactors, two were mothballed and two were cancelled. As a result of the environmental legal sabotage, the construction time was projected to be 12 to 14 years. WPPSS estimated that it would cost $12.1 billion to finish the two units, and that $8 billion of that cost would be interest charges on long-term bonds—*two thirds* of the total cost.

If the four nuclear plants planned by WPPSS had been completed, providing an additional 5,000 MW of electric generating capacity, even this year's drought in the Pacific Northwest would not have led to the crisis in energy supply that the region is now suffering.

By the time the last nuclear power plant came on line in the last decade, it was no wonder that its cost of producing electricity was not "competitive" with other sources. The actual cost of *building* plants had been declining for years, as seen in Figure 3. But the costs of dragging out construction for decades, and paying a king's ransom to borrow money, as well as the fear any utility would have of starting a project that could put it into bankruptcy court, had driven nuclear power out of the energy picture.

The energy crisis over the past year in California, and public recognition in New York and other states that the failure to build power plants over the last decade means there will be shortages, has resurrected an interest in nuclear energy in the United States. The Nuclear Energy Institute reports that a group of utility executives approached the organization last year, to set up a task force to examine what would be necessary to deploy a new nuclear plant. The idea is to form a consortium of companies that would order perhaps 10 or 20 plants, which would be standardized and would benefit from economies of scale of production.

No matter what plans the nuclear industry may put together, however, only a complete reversal of the financial and political policies that have wrecked the development and deployment of nuclear technology over the past 40 years will make a difference.

How Do Cells See Each Other?

by Colin Lowry

During the development of a multicellular animal, very complex cellular movements and migrations are required to build the form of an animal. This takes place as cells form layers of tissues, and tissues form organs. These events must be tightly coordinated in time and space. The individual movements of cells are crucial in determining the result of the process of development.

How do the cells know where they are going? How do they know the orientation and location of their own position, relative to other cells? These fundamental questions have led to the exciting discovery of how cells use electromagnetic radiation, in the form of specific wavelengths of light, to "see" each other, and to determine the distance and direction to other neighboring cells.

Almost 80 years ago, the Russian biophysicist Alexander Gurwitsch discovered mitogenetic radiation, the emission of very weak, but coherent electromagnetic radiation in the ultraviolet range from cells undergoing mitosis.[1] From his experimental work, Gurwitsch developed the concept of the cell as existing in a "biological field," a concept that allowed the cell to employ any or all of the electromagnetic spectrum to accomplish tasks necessary to maintain its living state.

Gurwitsch's experimental work was focussed primarily on the use of ultraviolet photons by cells to regulate the process of cell division in a tissue. More recently, another part of the electromagnetic spectrum has been identified, which is used by cells for a different function. Working at Northwestern University, starting about 10 years ago, Dr. Günter Albrecht-Buehler found that single cells were able to locate distant infrared light sources of very weak intensity, and that some of the cells migrated toward the light source.

Dr. Buehler viewed through the microscope the behavior of single cells isolated in a special chamber and exposed to near-infrared light of very low intensity. When the infrared light was in the range of 800 nm to 900nm wavelength, the cells responded by extending pseudopods toward the light source, and about 25 percent of them migrated and actually touched the source (Figure 1). However, there was a curious requirement for this behavior. The light had to be pulsed, and the cells responded more strongly to certain frequencies than to others, while totally ignoring a steady signal.

Dr. Günter Albrecht-Buehler, Professor of Cell Biology, Northwestern University

If the cell was exposed to two light sources, originating from different locations, the cell would either extend pseudopods toward one source, and then the other, or would extend toward both at the same time.

The implications of these initial experiments were tremendous. The cells could interpret the change in frequency in the light source, and modified their behavior accordingly. Also, the cells could identify the direction of the light source, and could distinguish one source from another! This meant that the cells must have a method of "seeing" in perspective, demonstrating they can judge distance and direction. For example, persons with only one eye cannot judge distances between objects correctly, as they have lost their depth perception. So, the cell must have the equivalent function of having two eyes—but, of course, it has no structure that resembles anything like an eye as we know it.

Cells 'See' Through Glass

In the next set of experiments, Dr. Buehler tested whether cells separated from each other by a thin plate of glass could "see" each other. The glass makes all chemical and physical contact between the cells impossible, leaving only optical means of communication. For the first experiments, cells grown from the cell type BHK, which have a distinct cell polarity with a long axis, were allowed to grow in a single layer, until very dense on one side of a thin glass plate. These cells oriented to each other with their long axes mostly in parallel, when grown in a single layer.

On the other side of the plate, BHK cells were plated at low density two days later, and allowed to attach and grow for only 7 hours. The BHK cells on the low-density face of the plate do not orient themselves randomly, and amazingly, 75 percent of these cells were found growing with their long axes traversing, or perpendicular to, the axes of the cells on the opposite side of the glass! Did the cells on the low-density face detect the orientation of the cells through the glass beneath them, and arrange themselves perpendicular to the other cell layer? Cells of this type normally grow in the body in layers, where the long axes of the cells traverse each other, and many other tissues are constructed from a weaving pattern of the different cell layers.

To find out if light transmission was

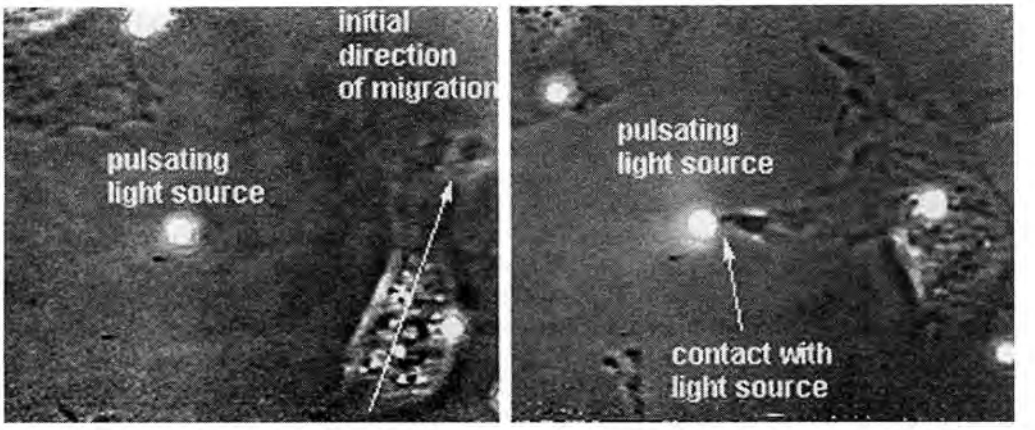


Figure 1
CELL RESPONSE TO NEAR-INFRARED, PULSED LIGHT
A cell (a) changes direction, and extends a pseudopod (b) contacting the latex bead that is scattering the near-infrared pulsed light.

Figures are courtesy of G. Albrecht-Buehler

responsible for the non-random growth patterns, the cells were regrown on plates that had been coated with a very thin layer of nickel-chromium. This metallic layer blocks 90 to 99 percent of optical transmission across glass. When the cells grew on these coated plates, the patterns were gone, and the orientation of the cells on the low-density side was random.

From this result, Dr. Buehler wanted to determine what part of the light spectrum the cells needed to transmit and receive, so he used a thin coating of silicone, which blocks light in the blue range, but is transparent for red and near-infrared light. When the cells were grown on silicone-coated plates, the non-random patterns returned, and the percentage of cells on the low-density side that traversed the axes of the cells on the opposite side was the same as in the experiments with uncoated plates.

Reflective Action

Now that the emission spectrum the cells were using to locate each other had been established, another question arose: Does a single cell find the location of other cells only by receiving emissions from other cells, or can it also emit its own near-infrared radiation and bounce it off the other cells, interpreting the reflected radiation? To try to answer this question, BHK cells were plated on one side of an uncoated glass plate, and allowed to grow to a high density. These cells were then killed and fixed by chemical preparations that leave the cell structure mostly intact.

On the other side of the plate, new BHK cells were cultured for 7 hours, and then analyzed for orientation patterns. Again, the cells oriented themselves with their long axes traversing those of the dead cells on the other side of the glass, although the percentages were slightly lower than in the previous experiment with live cells on the other side. This surprising result indicated to Dr. Buehler that the cells must be able to emit and receive by reflection their own near-infrared radiation, and determine the orientation of the dead cells on the other side of the glass.

Cellular Vision's Non-Linearity

It is important to realize that the use of the near-infrared spectrum by cells to locate their orientation and determine distances to other cells, is not a simple response to the quantity of energy of the light source. Near-infrared radiation has too little energy to have any photochemical effects on molecular bonds. The total energy of the light source is not important to the cell, but the pulsation frequency and the wavelength are very important.

Therefore, we are dealing with a complex, intelligently designed system of cellular vision, that probably has a lot in common with resonance phenomena. This concept of resonance, is found in Gurwitsch's work expressed as an idea of very low energy photons whose effect on the cell's function is multiplied by orders of magnitude. In other words, the initial energy of mitogenetic radiation photons is so low, it cannot translate linearly to the result, which is the induction of mitosis, an event requiring the cell to expend large amounts of energy.

In cellular vision, the energy of the near-infrared radiation is also very low, but the cell can interpret these signals, and initiate the very energy intensive processes of migration, or the directed growth of pseudopod extensions. It is clear we are not dealing with some simple phototaxis response.

Although Dr. Buehler had shown that cells can see each other, the type and character of the light signals was mostly unknown, and just as important was the question of how different cell types would respond to the same light signal. Could the cells be tricked into responding to light signals generated experimentally? Knowing the wavelengths the cells predominantly use for cellular vision, he designed a series of experiments using two different cell types, exposed to varying pulse frequencies of the light.

From previous work, Dr. Buehler found that 800 nm was the wavelength of near-infrared light the cells responded to most strongly. He selected two cell types known for their different motile characteristics, 3T3 fibroblasts, and CV1 epithelial cells. Fibroblasts are highly motile cells, and form connective tissues in the body. CV1 cells normally do not exhibit motile behavior.

Hundreds of individual cells were studied in the special microscope chamber. They were exposed to light pulses that were aimed at a small latex bead, which scattered the light, reducing the intensity the cells would receive by orders of magnitude. The behavior of the cells was characterized as attraction, repulsion from the source, or indifference (Figure 2).

Studying the 3T3 cells, Dr. Buehler

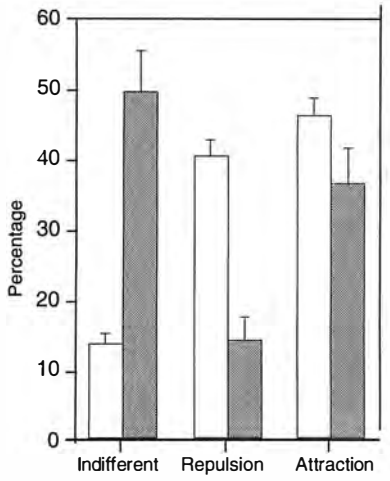


Figure 2
RESPONSE OF TWO CELL TYPES TO NEAR-INFRARED LIGHT
Comparison of the response of two cell types to the frequency range of the near-infrared light. CV1 epithelial cells are shaded bars; 3T3 fibroblasts are white bars. The error bars indicate standard deviations.

found that 88 percent responded to the light pulses between 0.13 hertz and 5.0 Hz. There was a critical frequency range between 0.5 and 1.0 Hz, where the response of the majority of the cells switched from repulsion to attraction. At 1.0 Hz, about 60 percent of the 3T3 cells were attracted to the light source, while at 0.7 Hz, about 55 percent were repulsed (see Figures 3 and 4).

How did the CV1 cells respond to the same light pulse frequencies? More than 50 percent of these cells responded, with 35 percent being attracted, and 15 percent being repulsed from the light source. However, the overall trend for repulsion and attraction related to pulse frequency was the opposite of the response trend for the 3T3 cells. So, two different cell types change their behavior in different ways when presented with the same light signals.

Another important result from these experiments was the determination of the maximum distance to the light source that the cells would still respond to. On average, animal cells are about 20 µm in diameter. From the experiments, it was found that light sources farther away than 60 µm were ignored by the cells.

When you consider that a migrating animal cell takes about 1.5 hours to cross 20 µm, it makes sense the cell would ignore light pulses in the near infrared from farther away. In the development of an embryo, some cell migrations take place over 6 to 10 hours before the cells reach their destination. The problem for the migrating cell is that its destination will not exist in the same form when it starts its journey as it will when the cell arrives there hours later. The entire form of the embryo will be changing rapidly, so looking ahead only 60 µm may prevent the cell from choosing the wrong path, as this amounts to about 5.5 hours of travel time for the cell.

Obviously, cellular vision of this type is not the only thing guiding the cell during migration in development, but it certainly must play an important role. Considering that dozens of cell types exist in an animal, the fact that each may respond differently to the same light pulse signal gives the organism yet another way to produce singularities required for the differentiation of specific tissues and structures of the body.

Structure of Cellular Eyes

What would the "eyes" of the cell look like? Is there an ideal structure that eyes in the cell would have? The first requirement is that the cellular components that make up the eyes, must be a pair of some type, because the cell can determine distances and orientation. There is an obvious candidate structure, known as the centrioles.

Centrioles are dense cylinder-like structures that exist at right angles to each other. They are part of the structure known as the centrosome in mammalian cells. The centrosome is an organizing center for the fiber network known as the cytoskeleton, which gives the cell its particular shape, and participates in the process of cell migration. Centrioles also are conveniently oriented to each other perpendicularly, so you could think of one mapping out longitude and the other the latitude of incoming near-infrared radiation.

Beyond these initial hypothetical reasons, there is some experimental work to support the idea of centrioles playing a role in cellular vision. Dr. Buehler has studied cells with some of their internal components removed, in the same experimental setup used to test the behavior of cells to light pulses. In these experiments with 3T3 cells, he has found that cells with their nucleus removed, can still respond and migrate towards the light source. The centrioles are located in the cytoplasm, outside of the nucleus. Even cells deprived of their golgi apparatus in the cytoplasm, still respond to the light. Centrioles are found in all motile cells, from protozoans all the way up to Man. Plant cells that never move do not have centrioles, but plant cells that become motile, such as sperm, create centrioles *de novo*. The structure of the centrioles themselves also gives the cell the ability to distinguish the angle of the incoming light.

Centrioles are made up of 9 or 13

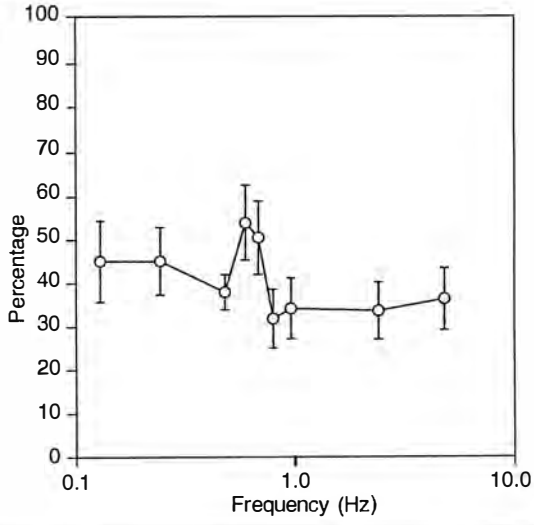


Figure 3
REPULSION AS A FUNCTION OF PULSE FREQUENCY
Percentage of 3T3 cells that are repelled from the light source at a given pulse frequency. The error bars indicate standard deviations.

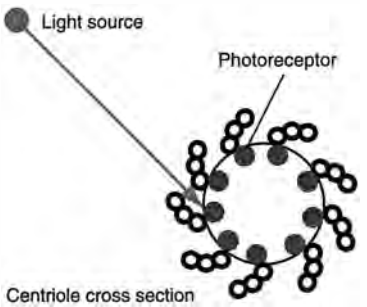


Figure 5
MODEL OF THE CENTRIOLE AS A CELLULAR EYE
The 9 tubes of the centriole act as blinds, allowing the light from the source to interact with one or only a few photoreceptors, which are proposed to be at the bottom of the blind. This structure would give a very precise determination of the angle of the incoming light. Two centrioles in perpendicular orientation would allow the mapping of the light source location in three dimensions

dense, tube-like structures, bound together in a spiral orientation forming a cylinder. Dr. Buehler proposes that there must be some type of photoreceptor in the centrioles, and that the pitch of the centriole tubes may act as "blinds," providing a way of increasing the angular resolution of the incoming light (Figure 5). The centrioles may indeed act as the eyes of the cell, although more work is required to determine how they function in this capacity. The larger question is, how does the cell interpret and respond to what it sees?

Cell Intelligence and Biological Field

It is inescapable to conclude that cellular vision requires some type of cell intelligence. Just as eyes give an animal the tools to see, the animal cannot move or change its behavior from the interpretation of images without intelligence. The intelligence of the cell is obviously not located in a structure analogous to the brain, but instead is an emergent property of the whole. The phenomenon of cellular vision, therefore, cannot be reduced to a single component of the cell, nor to a simple sum of its parts.

The inherent problems of studying living processes of the cell from a reductionist molecular standpoint, drew Dr. Buehler into cell biology. He received his Ph.D. in physics from the Technical University of Munich in 1972, and switched to cell biology shortly thereafter. Describing the thoughts that led to his current research, he said, "I was convinced that no molecule was possibly alive, and that the smallest recognizable life forms were somehow the emergent results of a large number of molecules and 'information.' Therefore, I turned to cells as the smallest autonomous unit of life for answers to the question how it was possible that large numbers of 'dead' molecules could come alive by carrying, exchanging and processing information."

Dr. Buehler first studied the similarities of the movements of related cells, finding them to be non-random. He then studied the function and structure of the centrioles in migrating cells, moving from those experiments to his current work on cellular vision. He was unaware of the work of Gurwitsch on biophoton emission when he began his research, although his experiments also confront the fundamental question of how the cell uses the electromagnetic spectrum in living processes.

The research of Dr. Buehler opens another window into the complex world of optical communication at the cellular level. This is only one area of the electromagnetic spectrum of the biological field, whose scope remains mostly unknown even today. Cellular vision in the near-infrared could lead to tremendous changes in our understanding of processes that involve cell migration and orientation. This is most obvious in the development of an embryo, and the formation of tissues, which are determined by cellular movements and migration.

The discovery also applies to the process of wound healing, tissue repair, and other immune system functions, and could be applied to the problem of metastasizing tumors. If we can learn how cells communicate optically in these processes, we may someday be able to modify the behavior of cells directly with light.

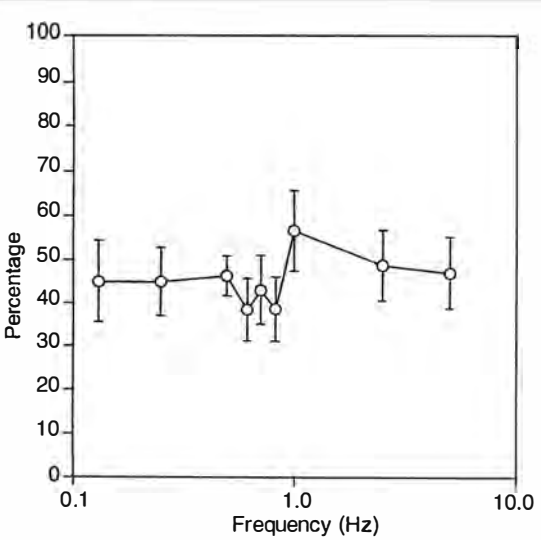


Figure 4
ATTRACTION AS A FUNCTION OF PULSE FREQUENCY
Percentage of 3T3 cells that are attracted to the light at a given frequency. Notice the shift from 0.7 Hz to 1.0 Hz. The error bars indicate standard deviations.

Notes

1. A series of articles on the work of Alexander Gurwitsch has appeared in *21st Century*. See, in particular, the two-part article by Gurwitsch's student, Dr. Michael Lipkind, "Alexander Gurwitsch and the Concept of the Biological Field," Summer and Fall 1998.

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2000 INDEX

21st CENTURY SCIENCE & TECHNOLOGY

Volume 13

AUTHOR INDEX

SUBJECT INDEX

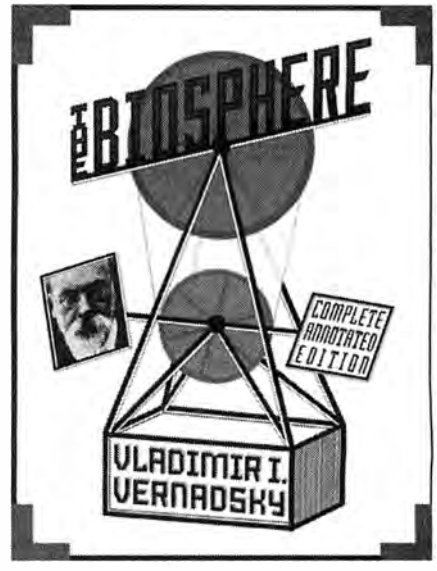
Agriculture

Space Science, Technology, and Exploration

BOOK REVIEWS

New Vernadsky 'Translation' Is Not Vernadsky

by Elisabeth Pascali



The Biosphere
Vladimir I. Vernadsky (1925)
D.B. Langmuir, trans.
Mark A.S. McMenamin, ed.
New York: Copernicus (Springer-Verlag), 1998
Hardcover, 192 pp., $30.00

Although we had hoped for better, this 1998 attempt at an English translation of two important essays by the great Russian biogeochemist Vladimir Vernadsky, is both a failure and a literary fraud. One need read no further than the translator's introduction, to discover that it is not a faithful translation of Vernadsky's seminal ideas, but rather an interpolation and rewriting by both the translator and editor. If we had wanted their opinion, we would have read their books. We wanted Vernadsky, and did not find him.

The English-speaking reader deserves better. There are only two other English renditions of these two essays, which Vernadsky wrote in 1925, and which were published in Russian and French. The first is an abridged edition put out in 1986 by the builders of the Biosphere 2 Project. This, according to the editors of the Copernicus edition reviewed here, is even more drastically redacted than their own. The second is an unpublished translation, drafted in the 1970s by D.B. Langmuir, which is the basis for this new edition.

Translator Langmuir is alarmingly frank in confessing his literary sin. In his 1977 introduction, included in this edition, he writes: "The revision presented here is a rather drastic one, in which the sequence of ideas in sentences and paragraphs has been rearranged in the interests of compactness and logical flow."

This error is compounded by editor and annotator Dr. Mark McMenamin, who tells us in his introductory remarks: "In this translation, the text has been rendered into more fluent English. In many places, this has involved adding words and phrases that will not be found in the original." Perhaps the translator and editor consider this to be fair warning. But how is the reader to know when he has encountered one of the many doctored and edited passages, in which Vernadsky's exposition and argument, and the rigor of his thinking, have been smudged?

Vladimir Ivanovich Vernadsky (1863-1945), who developed the concept of the biosphere.

An Example

In the process of publishing another paper by Vernadsky, which was printed in the Winter 2000-2001 edition of *21st Century,*[1] translator Rachel Douglas compared the Copernicus translation of *The Biosphere* to the original Russian. It was then that it came to light just how drastic are the revisions of Langmuir and McMenamin. A shocking example of fast and loose play with Vernadsky's ideas, occurs at the conclusion of Section 24 (p. 60). The subject is the coherence of the lawfulness of living processes, with the lawfulness of other observable domains.

Vernadsky wrote (as translated by Douglas): "Despite the extreme variability of life, there is no doubt that reproduction and growth in complexes of organisms (in living matter, as well as in individual organisms), i.e., their work of transforming solar energy into terrestrial chemical energy, are subject to invariable mathematical lawfulness. Everything is considered, and everything adapts itself, with the same precision, the same sort of mechanical performance, and the same subordination to

measure and harmony, as we see in the orderly motions of the celestial bodies, and are beginning to see in systems of atoms of matter and energy."

The mistranslation in the Copernicus edition guts this paragraph, excising the author's reference to the three levels—terrestrial, astronomical, and atomic, as follows: "In spite of the extreme variability of life, the phenomena of reproduction, growth, and transformation of solar energy into terrestrial chemical energy are subject to fixed mathematical laws. The precision, rhythm, and harmony that are familiar in the movements of celestial bodies can be perceived in these systems of atoms and energy."

The Real Vernadsky vs. Gaia

On top of the admittedly false translation presented in this volume, there is the problem of the extensive footnotes, which carry the implication that Vernadsky should be thought of as a predecessor (and implicitly an endorser) of the Gaia Hypothesis, first proposed by Dr. James Lovelock in 1979.

V.I. Vernadsky is one of the most important figures in 20th century science. His concepts of the *biosphere* and the *noosphere* raise the level of scientific discussion on the question "What is life?" far above the commonplace errors of reductionism and Information Theory that dominate academic biology today. Vernadsky studied under Dmitri Mendeleyev and Pierre Curie, and was a great admirer of Louis Pasteur and Bernhard Riemann. He took the best epistemology and methods of scientific investigation of the 19th century and applied them to the 20th century problems of nuclear technology, optical biophysics, and biogeochemistry (a field which he helped to create). He fought against the kind of irrationality that lurks behind the Gaia Hypothesis today, and the belief of the Raskolniki, or Old Believers, in Matushka Rus—which was the Russian version of a Mother Earth Goddess, in Vernadsky's day.

Dr. James Lovelock first hypothesized the idea of Gaia while working for NASA in the 1960s, as part of the team of scientists that designed the experiments to determine if there was life on Mars. He noticed that the Earth's atmosphere was not in static or dead equilibrium, as were the atmospheres of Venus and Mars. To explain the dynamic equilibrium, or planetary-scale homeostasis, it was necessary to take into account life. So far, so good. However, from there he accepted and published the idea that the planet as a whole must be a living being. In his second book, *Ages of Gaia* (1988), Lovelock writes:

"The name of the living planet, Gaia, is not a synonym for the biosphere—that part of the Earth where living things are seen normally to exist. Still less is Gaia the same as the biota, which is simply a collection of all individual living organisms. The biota and the biosphere taken together form a part but not all of Gaia. Just as the shell is part of the snail, so the rocks, the air, and the oceans are part of Gaia. Gaia as we shall see, has continuity with the past back to the origins of life, in the future as long as life persists. Gaia, as a total planetary being, has properties that are not necessarily discernible by just knowing individual species or populations of organisms living together. . . . Specifically, the Gaia hypothesis says that the temperature, oxidation, state, acidity, and certain aspects of the rocks and water are kept constant, and that this homeostasis is maintained by active feedback processes operated automatically and unconsciously by the biota."[2]

After 21 years, there is no widespread acceptance of this theory among professional biologists, although those who attack Gaia tend to do so for the wrong reasons. The most common argument used against it, is that, if it were true that Nature were following some unified plan, then that would violate the Darwinian axiom of natural selection (the "selfish gene" of each species acting on its own, fighting for survival). Among Lovelock's strongest supporters, is the American Dr. Lynn Margulis, Lovelock's principal collaborator, who was also the leading advocate of publishing this edition of *The Biosphere*.

Margulis has, independently of Lovelock, proposed an alternative mechanism for evolution, which she has termed endosymbiosis. Her theory is that eukaryote cells (cells that have a structure, such as mitochondria or a nucleus) developed as symbiotic consortiums of prokaryote cells (cells that do not have any internal structure). This has been generally accepted by the biological science community—after a long, uphill battle—as the explanation for certain parts of cell structure, such as the origin of chloroplasts.

Margulis thinks that the Gaia hypothesis, which treats the planet as a "super organismic system," helps to explain how evolution could have been a cooperative and not a competitive process. However, the scientific methods (to use the term loosely) of both Charles Darwin and James Lovelock are very shallow and short-sighted compared to the work of Vernadsky and his predecessors.

Gaia: Mascot of the New Age

A quick search on the Internet shows that Gaia has become the mascot of the New Age movement. The Gaia hypothesis has been used to justify the Malthusian outlook of the New Age, that mankind is fundamentally just another form of animal life, the same as a whale or a microbe, and a dangerous newcomer at that. According to Gaia's supporters, arrogant advances in technology are creating so much of a disturbance to the planet's homeostatic balance, that the anger of Gaia is being aroused.

James Lovelock clearly shares this

view. One of the New Age institutions which promotes the Gaia hypothesis is called the Gaia Society, whose chairman is Sir Crispin Tickell and whose co-presidents are James Lovelock and Lynn Margulis. Lovelock gave the opening remarks on Easter Sunday 1998, to a conference of the Gaia Society at Oxford, which he asked to be considered as a Sunday morning sermon. He summed up the ethics of Gaia as having two strong rules:

"The first rule states that stability and resilience in ecosystems, and on the Earth, requires the presence of firm bounds or constraints. The second rule states that those who live well with their environment favor the selection of their progeny. Imagine sermons based on these rules. Consider first the guiding hand of constraint. I can see nods of approval from the congregation. Their own experience of the need for a firm hand in the evolution of their families and in society concurs with the evolutionary experience of the Earth itself.

"The second rule, the need to take care of the environment, brings to mind a sermon on the abominable transgression of terraforming—the technological conversion of another planet into a habitat for humans. What is so bad about terraforming is its objective to make a second home for us when we destroyed our own planet by the greedy misapplication of science and technology. It is madness to think of converting with bulldozers and agribusiness the desert planet Mars into some pale semblance of the Earth when we should be improving our way of living with the Earth.

"The second rule also warns of the consequences of unbridled humanism. Early in the history of civilization, we realized that overreaching self-worship turns self-esteem into narcissism. It has taken almost until now to recognize that the exclusive love for our tribe or nation turns patriotism into xenophobic nationalism. We are just glimpsing the possibility that the worship of humankind can also become a bleak philosophy, which excludes all other living things, our partners upon the Earth. The hermit crab is not complete without its shell, all living things need the material Earth. Together with the Earth, we are one in Gaia."[3]

Three out of thirteen of the scientists who signed the Foreword to the English-

Anthony Howarth/Science Photo Library

James Lovelock, originator of the Gaia thesis. Gaia enthusiasts would like to graft their Gaia onto the science of Vernadsky.

Language edition of *The Biosphere* are Members of the Board of the Gaia Society: Lynn Margulis, Sir Crispin Tickell, and Peter Westbroek.

Vernadsky Speaks for Himself

Although it is true that Vernadsky thought of the biosphere as a unified whole, in which living processes had to be thought of as a planetary force, it is a gross injustice to imply that he would have agreed with James Lovelock. The Gaia Hypothesis is based on cybernetic feedback mechanisms. It is easily seen, even using the editors' problematic translation of this Copernicus edition, that Vernadsky warns against such inexact science in the very beginning (Section 12-13) of *The Biosphere*. He urges caution in going from empirical observations to theoretical constructs, exactly because making assumptions too early can cloud the observations, and lead to false theories. He notes that, even in the study of inert matter, it has been necessary to reject concepts that had long proved to be scientifically and logically necessary. Vernadsky then notes:

"The study of life faces even greater difficulties, because, more than in any other branch of the sciences, the fundamental principles have been permeated with philosophical and religious concepts alien to science. . . . Conclusions of the most careful naturalists in this area have been influenced, for centuries, by the inclusion of cosmological concepts that, by their very nature, are foreign to science. . . .

"13. The vitalistic and mechanistic representations of life are two reflections of related philosophical and religious ideas that are not deductions based on scientific facts. These representations hinder the study of vital phenomena, and upset empirical generalizations.

"Vitalistic representations give explanations of living phenomena that are foreign to the work of models—scientific generalizations by means of which we construct a unified theory of the cosmos. The character of such representations makes them unfruitful when their contents are introduced into the scientific domain.

"Mechanistic representations, that on the other hand see merely the simple play of physico-chemical forces in living organisms, are equally fatal to progress in science [pp.51-52]."

Even 50 years before the Gaia Hypothesis was proposed, Vernadsky had already rejected both Darwinism and the Gaia Hypothesis. His writing is a beautiful demonstration of how to make true scientific progress. The method of empirical generalizations, which are not immediately assumed to be hypotheses, was the method that Louis Pasteur used to overturn the mystical belief in spontaneous generation and to thoroughly develop the technique of vaccination. Vernadsky references the great empirical generalization that his teacher Dmitri Mendeleyev made, regarding the periodic system of chemical elements.

Vernadsky also disagrees with Lovelock on the nature of the Biosphere:

"The biosphere is at least as much a *creation of the Sun* [emphasis in the original] as a result of terrestrial processes [p.44]."

"Living matter gives the biosphere an extraordinary character, unique in the universe. Two distinct types of matter, inert and living, though separated by the impassable gulf of their geological history, exert a reciprocal action upon one another. It has never been doubted that these different types of biospheric matter belong to separate categories of phenomena, and cannot be reduced to one [p. 53]."

The editor, geologist Mark McMenamin, notes in a footnote on an earlier page, as part of the same discussion, that Vernadsky's view differs from a Gaia-like thesis which he helped to develop, called Hypersea: "Here Vernadsky is making a very clear distinction between living matter and the nonliving matter of the biosphere. This may be compared to the Trevirian concept of "matter capable of life" (Driesch 1914). Contrast this view with that of Hypersea theory (see McMenamin and McMenamin, 1994), where living matter and the biospheric living environment are one and the same, cutting out the bioinert component [footnote 38, p. 51]."

This distinction is very important. What Vernadsky is noting is that there is a physical discontinuity between living and non-living matter. Molecules used by living matter are in an entirely different chemical environment and "thermodynamic field" than those of inorganic matter. Also, although organic matter can pass back to an inorganic state (through death, or metabolic processing), it is not possible for inorganic matter to transform into organic matter.

This is a revolutionary discovery as important as that of Cardinal Nicholas of Cusa, who discovered that a curved line, the circumference of a circle, could not be approximated or measured by a straight line, because they are two different species of number (see his paper "On the Quadrature of the Circle."[4] This discovery led to a revolution in mathematical physics.

Unlike modern radical environmentalists, Vernadsky does not consider himself a member of an arrogant species, doomed to extinction. He discusses his idea of the distinction between man and other living species in other papers in more detail. However, even in *The Biosphere,* he is very clear on this point. In *The Biosphere,* he notes that Man is the one species capable of finding means to travel beyond the life-protecting ozone layer. He also notes that the adaptability of the Biosphere to new stresses is not static, and that its limits cannot be known:

"112 . . .The extreme limits of the biosphere probably represent absolute conditions for all organisms. These limits are reached when any one of these conditions which can be expressed as independent variables of equilibrium, becomes insurmountable for living matter; it might be temperature, chemical composition, ionization of the medium, or the wavelength of radiations.

"Definitions of this kind are not absolute, since adaptation gives organisms immense ability to protect themselves against harmful environmental conditions. The limits of adaptation are unknown, but are increasing with time on a planetary scale.

"Establishing such limits on the basis of known adaptations of life requires guesswork, always a hazardous and uncertain undertaking. Man, in particular, being endowed with understanding and the ability to direct his will, can reach places that are not accessible to any other living organisms."

"Given the indissoluble unity of all living beings, an insight flashes upon us. When we view life as a planetary phenomenon, this capacity of *Homo sapiens* cannot be regarded as accidental. It follows that the question of unchanging limits of life in the biosphere must be treated with caution [pp. 118-119]."

The writings by Vernadsky, his collaborators, and predecessors, are a potential source of a new Renaissance in biogeochemistry, climatology, and even environmental science. It is only necessary to be willing to throw out the tired old axioms of Darwinism and Gaia-ism. It is fitting that Dr. Lovelock points out in his opening remarks, referenced above, that Sir Crispin Tickell is the great, great grandson of Thomas H. Huxley, the defender and promoter of Charles Darwin's theory of the origin of species. "Sir Crispin is following in the family tradition by doing the same service for Gaia," he writes.

These two theories—Gaia-ism and Darwinism—are two sides of the same red herring, and should be swept aside, so that real progress can be made.

Notes

1. "Problems of Biogeochemistry II: On the Fundamental Material-Energetic Difference between Living and Nonliving Natural Bodies in the Biosphere" (1938).
2. *The Ages of Gaia*, Lovelock's second book, as quoted at http://www.magna.com.au
3. From the Gaia Society website: www.gaiasociety.org
4. An English translation of this Cusa essay is available in *Fidelio* magazine, "On the Quadrature of the Circle" (1450), by Nicholas of Cusa, *Fidelio*, Spring 1994, p. 56.

Bugs Don't Lie

by J. Gordon Edwards, Ph.D.

A Fly for the Prosecution: How Insect Evidence Helps Solve Crimes
Dr. M. Lee Goff
Cambridge, Mass.: Harvard University Press, 2000
Hardcover, 225 pp., $22.95

Entomologist Lee Goff provides more details about maggots in corpses than most people really want to know. He does it so well, however, that it certainly holds one's attention.

His descriptions of the roles played by maggots and other insects in the consumption of dead bodies are impressive, and it is obvious that such details have guided many court trials to successful conclusions. Differences of insect activities in human corpses found in salt water, fresh water, polluted water, damp soil, or dry habitats, and in airtight boxes, automobiles, apartments, and clothes closets are discussed, as well as the effects on bodies hanging from ropes, or stuffed beneath buildings.

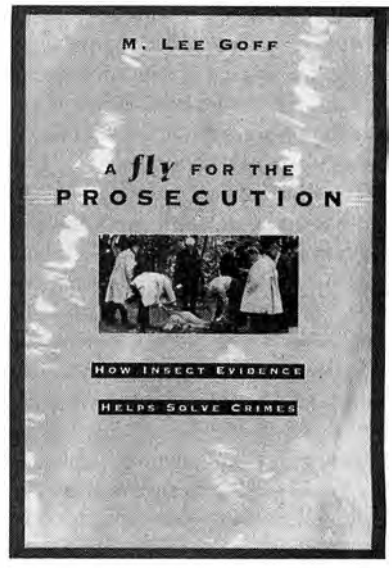
In each case, Dr. Goff lists the major insects involved and explains what environmental conditions were responsible. Although maggots can be easily identified by characteristic differences in their caudal spiracles and other structures, the author apparently relied most often on rearing the maggots to maturity and then identifying the results.

The fly adults are attracted even to faint odors, and they deposit their eggs within the first 24 hours of favorable weather after the victim's death. Details are provided for dozens of cases that the author has investigated, and he outlines the basic dietary requirements of each kind of scavenger. In addition to eating the dead flesh, maggots almost immediately invade the natural orifices of the head and pelvic regions.

The most common maggots found in corpses were in the family *Calliphoridae* (Blow Flies). In Hawaii, the most common maggots were those of two species of *Chrysomyia,* but elsewhere, the most common invaders were *Phaenicia sericata, Phormia regina,* and species of Flesh Flies (family *Sarcophagidae).* Flesh Flies do not deposit eggs, but instead produce living maggots. Black Soldier Flies *(Hermetia illuscens)* are also frequently present. Species of *Fannia* are more common in wet or very damp corpses. Species of beetle families *Staphylinidae, Sliphidae,* and *Dermestidae,* as well as wasps, ants, and Macrocheliod mites, all feed on insects that are attracted to the dead flesh.

"A decomposing body is in some ways like a volcanic island that has recently emerged from the ocean, for it is a resource waiting to be colonized by plants and animals," Goff writes. After its appearance in the environment, the corpse passes through stages, from the Fresh Stage, to the Bloated Stage, the Decay Stage, the Post-Decay Stage, and the Dry Stage. There is also a "Drip Zone," he says, beneath hanging corpses.

These stages differ greatly with regard to the type of insects that are attracted. For legal purposes, it is useful to be able to prove how long the bodies have been dead, and the author gives details of evidence presented in court, in regard to these stages, which has frequently resulted in the sentencing of murderers who might otherwise have escaped conviction.



Temperature, humidity, and the numbers of insect species are closely correlated. In a week or two, all of the fly larvae will usually have pupated, and the adult flies will be gone. After the corpse has become very dry and the exoskeleton has hardened, it is fed upon by only a few kinds of insects, such as Dermestid beetles. The hardened tissues contain chemicals that cannot be released, except when ingested by chewing beetles.

One interesting finding that the author reports is that when maggots feed on the corpses of human beings who were heavy users of marijuana, cocaine, heroin, or Ecstasy, they stored amounts of those drugs. If cocaine was present, the maggots grew much faster than usual—a fact that must be considered when determining the time that has passed since the victim's death.

This little book will be especially valuable to entomologists who are considering a career in forensic biology, as well as an interesting reference for many general and medical entomologists.

J. Gordon Edwards is a professor emeritus of entomology at San Jose State University in California, where he has taught biology and entomology (including medical entomology) for more than 50 years.

Letters

Continued from page 9

UNSCEAR 2000, in 1986, in contaminated regions of Belarus and Ukraine, the average registered thyroid cancer incidence in children was 0.2 per 100,000. There were no data in this year from Russia. A substantial increase in registered thyroid cancers occurred in the three countries after 1989. However, in Russia, the first increase (9.1 per 100,000) was registered already in 1987, one year after the accident.

This suggests a lack of influence of radiation exposure, as the latency period for radiation-induced thyroid cancers is 5 to 9 years. In the period 1990-1998 the incidence of registered thyroid cancers in contaminated regions of Belarus was 4.5 per 100,000, that is, an increase by a factor of 22.5. In all contaminated regions of the Ukraine, the thyroid cancer incidence in this period was 0.41 per 100,000, that is, an increase by a factor of 2. In the Ukraine, the greatest increase was in the region of Kiev: 2.1 per 100,000 in 1990-1998, an increase by a factor of 4.2 from the rate in 1986 of 0.5 per 100,000.

The occult thyroid cancers were reported to occur in various countries with an incidence ranging between 5,600 to 35,600 per 100,000. There is no difference between the histological form of occult thyroid cancers, and the cancers registered in the regions affected by the Chernobyl fallout. These mostly papillary occult carcinomas are described as histologically invasive, and locally aggressive, and in this respect they do not differ from the "Chernobyl" cancers.

Corrections

- The name of the artist, Chesley Bonestell, was inadvertently omitted from his illustration on p. 58 of the Winter 2000-2001 issue in the article "Space Station Begins New Era of Spaceflight." His illustration, shown here, is of the 1950s space station concept of Wernher von Braun.
- The correct address for the website of Dr. C.S. Prakash, who answered a letter attacking his viewpoint on biotechnology by the head of Greenpeace Canada in the Winter 2000-2001 issue, is http://www.agbioworld.org.

Books Received

In Code: A Mathematical Journey, by Sarah Flannery with David Flannery. New York: Workman Publishing, 2001. Paperback, 323 pp., $24.95.

Dark Remedy: The Impact of Thalidomide and Its Revival As a Vital Medicine, by Trent Stephens and Rock Brynner. Cambridge: Perseus Publishing, 2001. Hardcover, 240 pp., $26.

Space, Time, and Matter and the Falsity of Einstein's Theory of Relativity, by Kamen George Kamenov. New York: Vantage Press, 2000. Paperback, 166 pp., $12.95.

The Little Ice Age: How Climate Made History, 1300-1850, by Brian Fagan. New York: Basic Books, 2001. Hardcover, 246 pp., $26.

Travels to the Nanoworld: Miniature Machinery in Nature and Technology, by Michael Gross. Cambridge, Mass.: Perseus Publishing, 2001. Paperback, 254 pp., $16.00.

Not by Fire But by Ice: Discover What Killed the Dinosaurs and Why It Could Soon Kill Us (second ed.), by Robert W. Felix. Bellevue, Wash.: Sugarhouse Publishing, 2000. Paperback, 255 pp., $15.95.

The Road Since Structure, by Thomas S. Kuhn. Philosophical Essays, 1970-1993, with an Autobiographical Interview. James Conant and John Haugeland, Eds. Chicago: The University of Chicago Press, 2000. Hardcover, 335 pp., $25.

Kepler's Philosophy and the New Astronomy, by Rhonda Martens. Princeton: Princeton University Press, 2000. Hardcover, 201 pp., $37.50.

Legal Alchemy The Use and Misuse of Science in the Law, by David L. Faigman. New York: W.H. Freeman, 1999. Hardcover, 256 pp., $24.95.

Undue Risk: Secret State Experiments on Humans, by Jonathan D. Moreno. New York: W.H. Freeman, 1999. Hardcover, 347 pp., $24.95.

Mathematics: Its Content, Methods, and Meaning, by A.D. Aleksandrov, A.N. Kolmogorov, and M.A. Lavrent'ev, (three vol. bound as one; reprint from 1963). Mineola, N.Y.: Dover Publications, Inc., 1999. Paperback, 1,120 pp., $29.95.

The Implementation of China's Science and Technology Policy, by Q.Y. Yu. Westport, Conn.: Greenwood Publishing Group, Inc., 1999. Hardcover, 256 pp., $65.

The Search for Life on Mars by Malcolm Walter. Cambridge, Mass.: Helix/Perseus Books, 1999. Hardcover, 170 pp., $25.00.

Construction: Building the Impossible, by Nathan Aaseng. Minneapolis: The Oliver Press, Inc., 2000. Hardcover, 144 pp., $19.95.

The End of Time: The Next Revolution in Physics, by Julian Barbour. New York: Oxford University Press, 2000. Hardcover, 371 pp., $25.

Illuminating Life: Selected Papers from Cold Spring Harbor, Vol. 1, (1903-1969). Jan Witkowski, ed. Plainview, N.Y.: Cold Spring Harbor Press, 2000. Hardcover, 383 pp., $25.

Supersymmetry: Unveiling the Ultimate Laws of Nature, by Gordon Kane. Cambridge, Mass.: Helix/Perseus Books, 2000. Hardcover, 199 pp., $26.

The Chronological Encyclopedia of Space, by Robert Zimmerman. Phoenix: The Oryx Press, 2000. Hardcover, 410 pp., $85.

The Birth of Time: How Astronomers Measured the Age of the Universe, by John Gribbin. New Haven: Yale University Press, 2000. Hardcover, 237 pp., $22.50

The Dream of Spaceflight: Essays on the Near Edge of Infinity, by Wyn Wachhorst. New York: Basic Books, 2000. Paperback, 108 pp. $22.

Microbes and Man, by John Postgate. New York: Cambridge University Press, 2000. Paperback, 373 pp., $19.95.

Engines of Enterprise: An Economic History of New England, Ed., Peter Temin. Cambridge: Harvard University Press, 2000. Hardcover, 328 pp., $24.95

The Chornobyl Accident: A Comprehensive Risk Assessment, Ed., George J. Vargo. Columbus, Ohio: Battelle Press, 2000. Hardcover, 271 pp.

Lives & Legacies: An Encyclopedia of People Who Changed the World Scientists, Mathematicians, and Inventors, Ed. Doris Simonis. Phoenix, Ariz.: Oryx Press, 1999. Hardcover, 244 pp.

Build Your Own Robot! by Karl Lunt. Natick, Mass.: A.K. Peters, 2000. Paperback, 574 pp., $34.

The Genius of Science: A Portrait Gallery of Twentieth-Century Physicists, by Abraham Pais. New York: Oxford University Press, 2000. Hardcover, 356 pp., $30.

Lucifer's Legacy: The Meaning of Asymmetry, by Frank Close. New York: Oxford University Press, 2000. Hardcover, 259 pp., $27.50.

Protostars and Planets IV, Eds. V. Mannins, A.P. Boss, and S.S. Russell. Tucson, Ariz.: University of Arizona Press, 2000. Hardcover, 1,700 pp., $95.

Rube Goldberg, by Maynard Frank Wolfe. New York: Simon & Shuster, 2000. Paperback, 192 pp., $25.

The Last Man on the Moon: Astronaut Eugene Cernan and America's Race in Space, by Eugene Ceman and Don Davis. New York: St. Martin's Press, 2000. Paperback, 356 pp., $14.95.

Science & Technology Almanac 2000, William Allstetter, Exec. Ed. Phoenix, Ariz.: Oryx Press, 2000. Paperback, 509 pp., $65.

Nuclear Legacy: Students of Two Atomic Cities, Maureen McQuerry, Ed. Columbus, Ohio: Battelle Press, 2000. Hardcover, 306 pp., $22.50.

The Brain's Sense of Movement, by Alain Berthoz (translated by Giselle Weiss). Cambridge: Harvard University Press, 2000. Hardcover, 337 pp., $45.

Turn Right at Orion: Travels Through the Cosmos, by Mitchell Begelman. Cambridge: Perseus Publishing, 2000. Hardcover, 256 pp., $25.

Gödel: A Life of Logic, by John L. Casti and Werner DePauli. Cambridge: Perseus Publishing, 2000. Hardcover, 224 pp., $25.

The Crest of the Peacock: Non-European Roots of Mathematics, by George Gheverghese Joseph. Princeton, N.J.: Princeton University Press, 2000 Paperback, 455 pp., $16.95.

Exploration & Exchange: A South Seas Anthology 1680-1900, Jonathan Lamb, Vanessa Smith, and Nicholas Thomas, Eds. Chicago: The University of Chicago Press, 2001. Paperback, 346 pp., $18.

Science and Technology Encyclopedia. Chicago: The University of Chicago Press, 2000. Paperback, 572 pp., $22.50.

Weather: How It Works and Why It Matters, by Arthur Upgren and Jurgen Stock. Cambridge: Perseus Publishing, 2000. Hardcover, 223 pp., $25.

The Mir Space Station: Russia's National Pride

The History of Mir: 1986-2000
Rex Hall, ed.
London: The British Interplanetary Society, 2000
Paperback, 112 pp. $46.00

When the Mir station was launched in 1986, the Soviet Union, characteristically, released little detailed information about it. But during the more than three years that American astronauts lived with their Russian colleagues aboard the Mir space station, from 1995-1998, for the first time in the West, much was written about the astronauts' adventures.

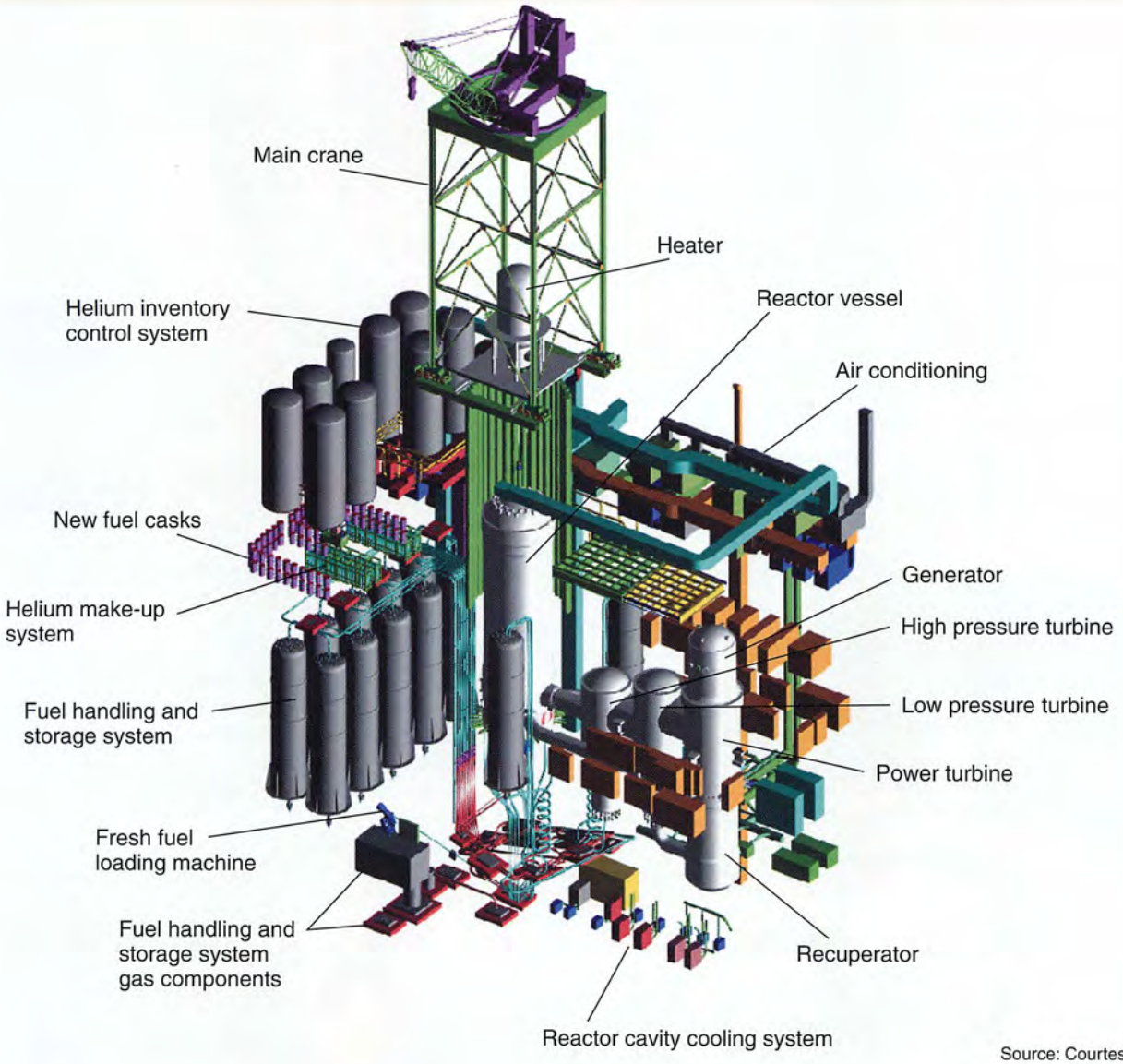
Unfortunately, these articles focussed mainly on a fire on the station, the collision with an unmanned Progress vehicle, and the resulting decompression of one of the station's laboratories, along with an array of equipment failures. Consequently, the accomplishments aboard Mir were little known.

This new contribution to space history from the British Interplanetary Society provides an inside view of the development of Mir, a tour of the station, a comprehensive table with mission data for all of the 29 crewed missions, an explanation of the scientific research facilities and experiments on Mir, and a review of the Shuttle-Mir program and other foreign visitors to Mir. It concludes with the plans for the disposal of Mir.

The stunning photographs and the detailed graphics throughout the book, allow the reader to get to know the Mir station, as the magnificent technological achievement that it was, with a legacy that continues in the International Space Station, now under construction. It is a very useful reference for both the layman and the specialist, in documenting the operational life of this extraordinary space facility.

—Marsha Freeman

SOUTH AFRICA'S PBMR: A MELTDOWN-PROOF REACTOR



Source: Courtesy of Eskom

The Pebble Bed Modular Reactor (PBMR), now under development by the South African company Eskom, is shown here with its main power system and support systems.

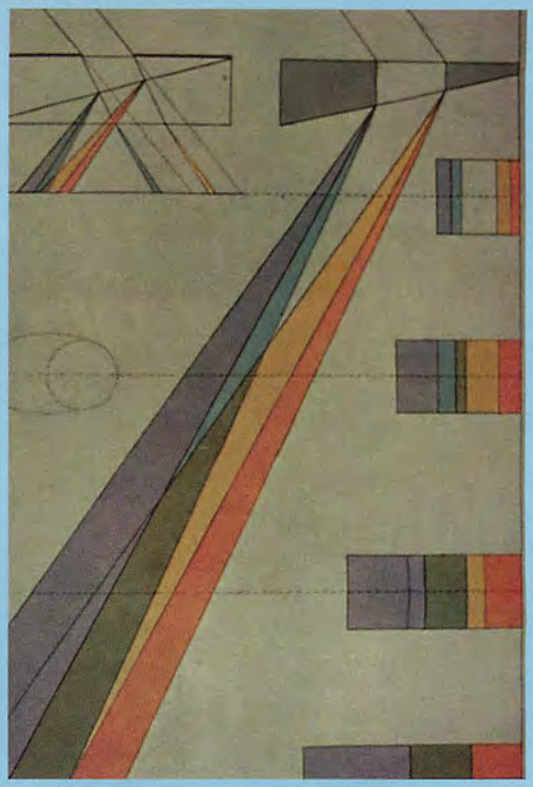
As described in the Nuclear Report, the PBMR and its cousin, the General Atomics GT-MHR (see front cover), are both helium-cooled high-temperature reactors with direct-cycle gas turbines, which eliminate the conventional steam cycle. These reactors encase the nuclear fuel in tiny ceramic spheres (instead of the familiar domed containment buildings of conventional nuclear plants).

The two designs have inherent and passive safety features, which make them meltdown proof: In brief, the reactor's design prevents it from getting hot enough to split open the fuel particles. If there is a coolant failure, the reactor shuts down on its own, without any human intervention necessary.

The major differences in the PBMR and GT-MHR designs are in the type of fuel assembly, and the amount of power produced. The fuel for the GT-MHR is shaped into rods, while the PBMR fuel is fashioned into tennis-ball-sized "pebbles." The PBMR is 112 megawatts electric, while the GT-MHR is 285 MWe.

PBMR fuel consists of tiny particles of uranium oxide, coated with layers of ceramics and silicon carbide, forming an impenetrable barrier, which contains the fuel. The particles are then mixed with graphite and molded into pebbles, about 310,000 of which fill the reactor vessel. An additional 120,000 graphite balls serve as moderator.

In This Issue:



GOETHE'S CHALLENGE TO NEWTON'S THEORY OF COLOR

When light originating from a wide source, such as a window, is passed through a prism, the spectrum of light is split into two parts, separated by a colorless band in the middle, as illustrated in this color plate from Johann Wolfgang von Goethe's *Theory of Color* (1808). As Ralf Schauerhammer shows in our feature section, Goethe supposed that color arises from the interaction of light and dark, and provided a valid explanation of the split spectrum on this hypothesis. His view was quite different from that of Newton, in which the colors are considered primary, and white light is supposed to be their combination.

Goethe, the poet, was also a great scientist. He made great contributions to botany and physiology, including the first identification of the human intermaxillary bone. But, despite penetrating criticisms of the weakness of Newton's theory of color, Goethe's stubborn insistence on a method which stressed the primacy of the phenomena prevented his finding a clear solution to Newton's error.

Plate V from Goethe's Theory of Color. *Light from a wide source, such as a window (top right) is passed through a prism, splitting the spectrum, and leaving a colorless band in the middle.*

Goethe's *Collected Works*, Vol. 12, *Johann Wolfgang von Goethe: Scientific Studies*, Ed. and Trans. Douglas Miller (Princeton University Press, 1995)

Brazil's Angra 1. At right is Guilherme Camargo.

HOW BRAZIL'S NUCLEAR ASSOCIATION DEFEATED GREENPEACE

In an interview that should be required reading for the nuclear community, among others, the director of the Brazilian Nuclear Energy Association tells how they waged war against Greenpeace's antinuclear campaign—and won. Guilherme Camargo describes how the Nuclear Association took the gloves off to battle Greenpeace, whose lying propaganda campaign had silenced political supporters and terrified the population, totally destroying Brazil's nuclear program in the early 1990s. Today, Brazil's second nuclear plant, Angra 2 is on line, and plans are moving forward for Angra 3.

In contrast, as Marsha Freeman reports in "Who Killed U.S. Nuclear Energy," the U.S. nuclear industry failed to attack its environmentalist foes, and allowed itself to be sacrificed on the "free market" altar.