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The Beautiful Species: Mankind

Vladimir Vernadsky vs Bertrand Russell

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150 Years of Vernadsky

Features

News

ECONOMICS

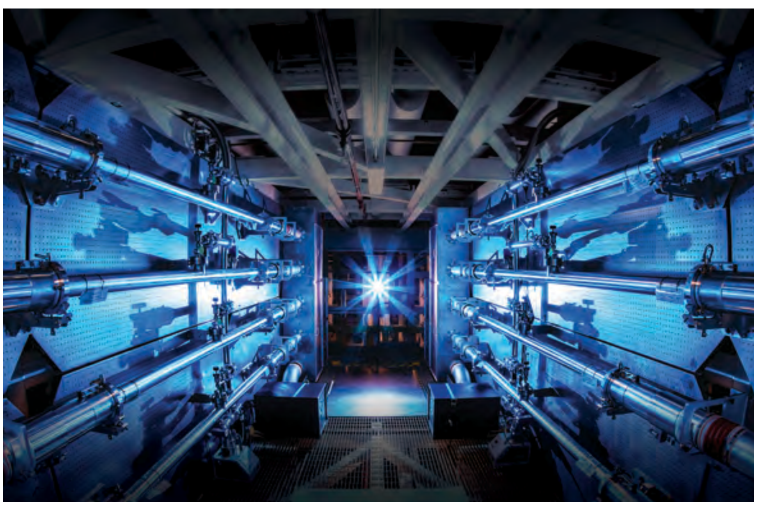
SPACE

Departments

EDITORIAL:

REVIEWS

SPECIAL REPORT SAMPLE



On the Cover: The preamplifiers of the National Ignition Facility at Lawrence Livermore National Laboratory are the first step in increasing the energy of laser beams as they make their way toward the target chamber. The total power of the laser is 500 terawatts, 1,000 times more power than the United States uses at any instant in time. The National Ignition Facility is a fusion experiment based on inertial confinement of the fusion fuel.
Photo credit: Damien Jemison/LLNL

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EDITORIAL

The Power of Humanity

by Jason Ross

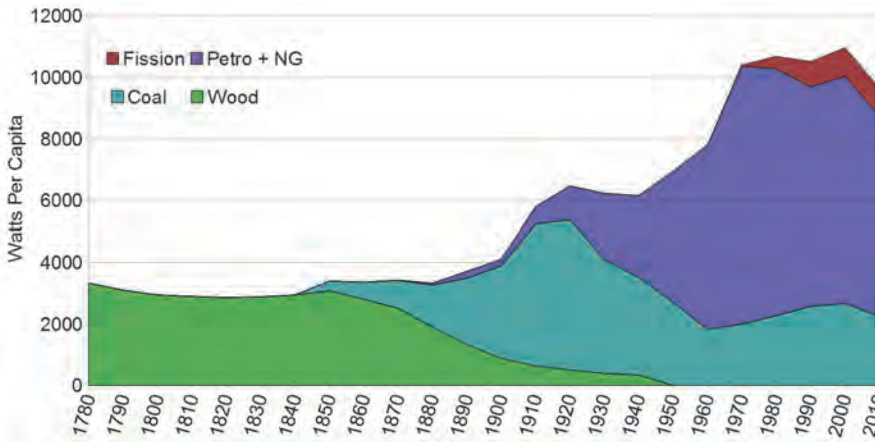
Unlike the developments in biology generally, human evolution occurs not by changes in genes, but by changes in behavior, predicated on discoveries which qualitatively expand our knowledge of the world around us, and discoveries of the best means of social organization for implementation of such discoveries. This "evolutionary" trend can be seen in a review of power sources over the history of the United States, which reveals a recurring pattern: new power sources are introduced, which rapidly grow, displacing earlier forms of power, and are then replaced by the next higher form. The introduction of coal replaced wood as a source of energy (freeing it to be used exclusively as a building material). Petroleum and natural gas then displaced coal as fuel sources (see figure below).

No in-depth data analysis is required to realize that this process has since come to a halt. The introduction of nuclear power did not have the same effect; the number of commercial nuclear reactors today is the same as it was two dozen years ago, the development of fusion has not yet occurred, and other uses of fission, including for construction, considered a natural matter of course in the 1960s, have never been applied to practice.

Coming after the assassination of President John F. Kennedy, the timing of this shift reveals something about the truly wicked motives underlying the commission of that deed. Without Kennedy's guidance, programs for space, science, technology, and economic development faltered (even the Apollo project, while resulting in the successful landing and return of men on the Moon, became a dead-end). This was the intended motive.

There is no scientific or technical reason that the commercial use of fusion has not yet been achieved. The willful underfunding of fusion, and the promotion of "technolgies" of net negative energetic value, such as the use of the centuries-old technology of windmills, is no accident. It is a goal of extinction.

UNITED STATES POWER PER CAPITA



The anti-human ideology (masquerading under the name "environmentalism") promotes a specific goal for mankind: having absolutely no effect on the supposedly static world around us, which is afforded a privileged status as something that must be preserved (for whom?). This outlook must be uprooted.

Today, this means breaking the power of monetary control over our national economy, and the restoration of sovereignty, though the re-instatement of the FDR-era Glass-Steagall law. It means making the development of an entire fusion-based platform of economy our *primary* long-term physical economic goal. It means fostering a new international order based not on maintaining hegemony in a static world, but on scientific and technological cooperation for the benefit of all nations. The recently printed *21st Century Science & Technology* Special Report on the Nuclear NAWAPA as the Gateway to a Fusion Economy provides a full basis for such development.[1] The economic platform encompassing fusion power and our mastery, through NAWAPA XXI, of the very geology of our planet—our river systems and our weather—is a coherent goal, one that binds together our greatest aspirations.

The present historical context does not present this outlook as an option, but rather as a necessity; any civilization which systemically rejects man's natural development as an increasingly powerful force in nature, renders itself unable to exist.

This Issue

We accompany the full policy-outlook in our special report, with a truly fantastic issue.

We continue our 2013 celebration of the sesquicentennial of Vladimir Vernadsky's birth, with his beautiful essay "Human Autotrophy." Written in 1925, near the end of his longest stay in Paris, Vernadsky takes up the increasing independence of man from his environment. Taking the term "autotroph," which typically refers to photosynthesizers (and a few other creatures) capable of producing their own food, Vernadsky examines to what extent human beings are autotrophs, both in the sense of feeding our physical bodies, as well as in our social reproduction, both material and energetic. Explicitly considering new forms of "fire," Vernadsky asks when we will develop the means to directly synthesize food itself!

Also in celebration of the great naturalist, we bring you an explosive article on "The 'Greening' of Vernadsky." Was it simply by cultural differences, honest error, or linguistic difficulties that Vernadsky is predominantly known (if known at all) in the West as the father of ecology? Far from it! This witting fraud is exposed as a project of the extended networks of the unabashedly evil Bertrand Russell. This is a fitting birthday present for Vernadsky, whose entire outlook was imbued with the knowledge that the mind of man was a new and powerful geological force in the universe, one not limited by the theories of Thomas Malthus.

Another feature covers economics, which is the science of bringing this human creative potential into being, socially, and is, thus, the science of sciences. The article "To Save the Nation, Restore the American System" shows that most of what passes as economic "common sense" propositions (e.g., that the "free market" is the foundation of our economic strength), are actually hoaxes, under which the United States could never have become the greatest industrial and agricultural power on Earth. From Hamilton to John Quincy Adams, Lincoln to FDR and JFK, the true American System of economic growth is revealed. This true history of U.S. development provides a foundation for leaping forward, economically, today.

Louis Pasteur is the subject of a feature article. While "pasteurization" may be a familiar process (or at least a familiar name), and the story of rabies is relatively well-known, Pasteur, himself, is not. His origins, outlook, and first major breakthroughs, bringing together the domains of optics, chemistry, and biology, are covered. His breakthroughs have fundamentally altered our way of life, and our relationship to the microscopic living world around us. Throughout, we get a sense of Pasteur's outlook: "Blessed is he who carries within himself a God, an ideal, and who obeys it... Therein lies the spring of great thoughts and great actions: they all reflect light from the Infinite."

As a case study of the great power of mankind over nature, we present progress on technology for weather modification. No longer a dream to be realized in a far-distant future, ionization systems are already being tested and implemented in various climates around the world, with very promising results.

We round out our issue with developments in the attack of the Obama Administration on the TVA, one year of *Curiosity,* the economic value of planetary defense, and more.

We hope that this issue helps to skewer the patently unscientific, plainly political, and frankly quite evil "philosophy" of Malthus and his ilk, and that it provides a firmer basis on which to build durable, specific conviction in the nature of mankind as a willfully evolving, and beautiful species. There is much that is truly new to do.

1. Available at: www.21stcenturysciencetech.com/Nuclear_NAWAPA.html

The "Greening" of Vladimir Vernadsky:
How The Russellites Sabotage Science

by William Jones

While the name Vladimir Vernadsky is still not as widely known here in the United States as it should be, given his prominence as one of the greatest scientific thinkers of the last century, the prevalent view of Vernadsky is largely based on a fraud perpetrated by the acolytes of that Malthusian genocidalist, Bertrand Russell, whom economist and statesman Lyndon LaRouche so aptly labeled the most "evil man in this century." To the extent Vernadsky is known within the American scientific community, he is largely seen as some sort of early ecological guru. The fraud of this view, tragically, has also become prevalent within Russia itself, where there is less excuse for it, as Vernadsky's works have been widely publicized in his native language. His name is often equated with that of wacko Gaia worshipper, James Lovelock, who belatedly also labeled himself a "Vernadskyian," although Vernadsky's world-view was, in fact, diametrically opposed to that Greenie mystic.

While Vernadsky was a natural scientist, who provided a solid scientific basis to the notion of the "biosphere," so much abused these days by the lunatic Greens, he saw the productive activity of man, a result of the biosphere, but transforming it into a higher state, as the most important element in its continued development. The stage of the biosphere characterized by the intellectual activity of man Vernadsky called the noösphere (*noös* is Greek for *mind*). Unlike the Greenies who believe that mankind should shut down its industrial activity in order to become "one with nature," Vernadsky believed that it was precisely man's creative ability to develop his technology, to develop new ideas resulting in productive breakthroughs, that provided man with essentially "unlimited resources." While insisting that such advances be implemented with scientific rigor, he was invariably opposed to placing restrictions on continued technological progress. Indeed, without such progress, Vernadsky knew the human race would quickly be on the road to extinction.

Now on the occasion of the 150th anniversary of his birth, it is fitting that we set the record straight and expose the fraud which has been imposed on an unknowing public by the Greenie acolytes of Russell and his cohorts.

Who Was Vladimir Vernadsky?

Vladimir Ivanovich Vernadsky was born in 1863, the son of economist Ivan Vasilievich and Anna Petrovna Vernadsky. The elder Vernadsky had been instrumental in the movement which led to the freeing of the serfs by Alexander II in 1861. He was also instrumental in introducing the works of the anti-Malthusian American economist Henry Charles Carey to the Russian intelligentsia, works which caused great enthusiasm among leading Russian economic circles. Carey's writings were rapidly

Archive Collection, Russian Academy of Sciences

Over the door of his office, Vernadsky kept the picture of George Washington that had always hung in his boyhood home.

translated into Russian. Young Vladimir, however, was more attracted to science than to economics. A portrait of George Washington graced his boyhood home, and later, the same portrait hung in his laboratory office. Abraham Lincoln was characterized by Vernadsky as a "hero for all times," paraphrasing a famous work by Russian writer, Mikhail Lermontov, "A Hero for Our Time." Vernadsky became acquainted at an early age, thanks to his father, with the work of the great 15th century scientist, Cardinal Nicholas of Cusa, whom Vernadsky, as a young professor, would laud in his lectures on the history of science, as the founder of modern science, leading into the Renaissance:

> One of the predecessors of the ideas of Copernicus was Cardinal Nicolas of Cusa (1401–1464) to whom I have previously referred. The son of German peasants, a faithful and passionate representative of the Catholic Church, he was one of the most original and prodigious minds of his time. In his works we find the seeds of a variety of ideas that have since become a part of contemporary thought. He died in 1464 soon after the discovery of printing, and his works were left in manuscript form, threatened with the same fate as was common with many of his predecessors, becoming known only much later, when all direct living contact with them had disappeared. But the works of Cusa avoided this fate. He was published 40 years after his death, but before his direct influence had waned. The first (now extremely rare) edition appeared in Rome in 1501. It was the first appearance in human thought since the ancient Greeks of the representation of the Earth turning on its axis, and revolving around some point in space, which Cusa considered to be, not the Sun, but rather a certain pole of the Universe… We see everywhere the influence of these ideas of Cusa, with which Copernicus was also acquainted. The significance of the works of Cusa was also seen in other areas of thought as well, and his the works are continually cited, primarily by the more innovative spirits, throughout the course of the 16th and 17th centuries.[1]

Archive Collection, Russian Academy of Sciences

Vernadsky, here in Prague in 1926, cannot cease to examine that phenomenon of life that so engaged his life's work.

Archive Collection, Russian Academy of Sciences

Vernadsky (on the right) photographed here together with other members of the left faction of the Russian Duma.

Studying the work of Alexander von Humboldt, particularly Humboldt's epic summary of the science of his day, *Cosmos*, Vernadsky devoted himself to the field of science as his best means of contributing to the progress of man, specializing in mineralogy and soil science, and later geochemistry. While maintaining a clear political engagement all his life, he felt that the progress he was making in the development of science represented his greatest contribution to his country and to the world. When the Bolsheviks took power in Russia, Vernadsky, one of the founders of the Constitutional Democratic (Kadet) Party traveled to Ukraine, still under the Whites, in order to avoid arrest. When he finally decided in 1921 to return to work in Bolshevik Russia where the Kadet Party was now banned, this put an end to any direct political activity on his part, although he would exert a great deal of influence with regard to science policy in the Soviet Union. Making his major discovery in the early 1920s of the inexorable role of life in the development of the Earth's surface, Vernadsky went on to make major breakthroughs in a variety of related fields, particularly in mineralogy and soil science, and created an entirely new field of science—biogeochemistry. Vernadsky also became the first person in Russia in the 1920s to lobby for a major research program for developing atomic energy.

1. Vernadskii, V.I. "Izbrannye trudy po istorii nauki" *Nauka*, Moscow, 1981. p.101.

Vernadsky is credited with the most comprehensive elaboration of the notion of the biosphere. His discovery of the unique quality of life to rapidly envelop over an entire area of the globe once it appeared on the scene, came to Vernadsky in his self-imposed exile in his beloved Ukraine during the period of the Russian civil war in the early 1920s. Vernadsky was astonished at first by the speed with which life proliferated and he took it upon himself to measure that rate. In the chaos of the Russian political world following the Bolshevik Revolution, Vernadsky also found solace and hope in his discovery of this elemental force of life to rapidly expand and proliferate, a force which he felt ultimately characterized the universe as a whole, including man's consciously directed social and economic development. Later, in 1939, Vernadsky would write:

> It is evident that the phenomenon of the expansion over the entire surface of the planet by a single species developed broadly in the case of aquatic life such as microscopic plankton in lakes and rivers, and with some forms of microbes, essentially also aquatic, on the thin film of the Earth's upper surface, and was disseminated through the troposphere. For larger organisms, we observe this almost in full measure with certain plants. For man this begins to appear in our time. By the 20th Century the entire globe and all the seas have been encompassed by man. With the rapid progress of communications, mankind is able to maintain continual contact with the entire world, and in no place is he alone or helplessly lost in the immensity of Earth's nature.[2]

In the same way that life becomes a predominant force in the lithosphere, bringing to it new processes which enrich and enhance it, so too does man's productive activity become an element in the biosphere, enriching and enhancing its productivity. This was characterized by the increase of energy throughput occasioned by man's activity and by the ability of man to support ever more efficiently an ever-increasing population. This is due to man's development of technology, a result of his noetic activity. And, placed on the cusp of a new century with the discovery of the atom, Vernadsky felt that the rate of development of technological progress was exponentially increasing. Writing in the 1930s, Vernadsky states:

> In the course of the last half millenium, from the 15th to the 20th Century, the development of man's strong influence over his surrounding nature and his comprehension of it, continued apace, growing ever more powerful. During this period the entire surface of the planet was encompassed by a single culture: the discovery of printing, a knowledge of all earlier inaccessible areas of the globe, the mastery of new forms of energy—steam, electricity, radioactivity, the mastery of all the chemical elements and their utilization for the needs of Man, the creation of the telegraph and the radio, the penetration into the surface of the Earth to the depth of one kilometer by boring, and the ascension of men in aerial machines to a height of more than 20 kilometers from the surface of the Earth, and of mechanical devices, to a height of more than 40 kilometers. Profound social changes, having been given support by the broad masses, thrust their interests into the first rank, and the question of eliminating malnutrition and famine, became a realistic option that could no longer be ignored.[3]

These words of Vernadsky are a far cry from any "Green" manifesto, which one would expect from his depiction as a proto-ecologist.

Vernadsky's Outlook

Vernadsky was well aware that his new conception of the biosphere was a ground-breaking one. He also knew that it required a larger audience in order to achieve its full import. While his first major work on the topic, *The Biosphere*, was quickly translated and published in French in 1929, the publication of his other writings would take a longer time to appear in translation, if at all, particularly with regard to an English translation. By the 1930s, Vernadsky was working on a series of papers, under the general title "Problems of Biogeochemistry," which summarized his mature views on the role and meaning of the biosphere and on man's increasingly preponderant role

Archive Collection, Russian Academy of Sciences

Much of Vernadsky's legacy lies in numerous manuscripts now preserved by the Russian Academy of Science.

2. Vernadsky, V.I. "Scientific Thought As A Planetary Phenomenon," *21st Century Science & Technology*, Spring-Summer 2012. p. 19.

3. *Ibid*., p. 30.

in its development. He was particularly anxious to have these papers published in English, to make the English-speaking scientific world fully aware of his new conception of man and the universe.

G. Evelyn Hutchinson was a member of that stable of characters who followed Bertrand Russell's population-control agenda.

The presence in the United States of Vernadsky's son, George, and of his daughter, Nina, both of whom had emigrated after the Bolshevik Revolution, put them in an ideal position to foster knowledge of their father's work here, even as it was taking shape in Russia. Also at Yale was a young Russian professor, Alexander Ivanovich Petrunkevitch, the son of one of Vernadsky's political mentors and close collaborators in the Kadet movement, Ivan Ilyich Petrunkevitch. Alexander Ivanovich had also been a former student of Vernadsky, and, after his emigration, became a zoologist at Yale, specializing in the study of spiders.

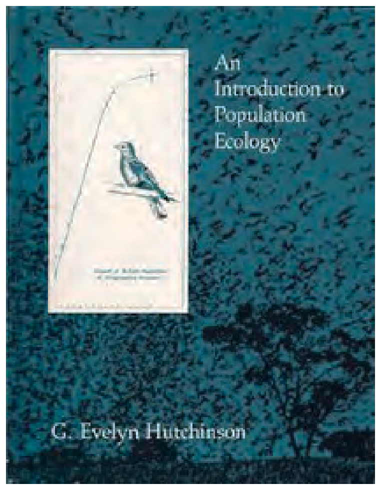
George Vernadsky was a professor of history at Yale University. Also at Yale was a British geologist and limnologist named G. Evelyn Hutchinson. Hutchinson was something of a typical by-product of the inter-war period at Britain's institutes of higher learning, particularly at Cambridge, where Hutchinson received his education. This was at the time a hotbed of Darwinism, Malthusianism, and philosophical reductionism. Names like Julian Huxley, J.B. Haldane, Bertrand Russell, anthropologist Gregory Bateson, as well as novelist, H.G. Wells, are prominent in this context. Bateson and Haldane were particularly close friends of Hutchinson at Cambridge. What united this crowd was their commitment to Darwinism and to a neo-Malthusian world outlook, which has always remained at the heart of the British imperial world-view.

Vernadsky early realized that Malthus's predictions were fundamentally flawed.

The position of Malthus, the classic spokesman of zero population growth, is too well known to dwell on here. But also Charles Darwin, who essentially viewed man as another form of beast, somewhat like a clever ape, took his cue from the work of Malthus. As he himself admits, it was a reading of Malthus's *An Essay on the Principle of Population* which prompted Darwin to compose his *Origin of Species*. Vernadsky had during his student days encountered the work of Pastor Malthus on population, and rejected it outright. Referring to Malthus' fundamental thesis, Vernadsky writes:

> Malthus doesn't realize that his fundamental results lead to entirely different conclusions. You might say that they are simply not true, because he did not take into consideration the fact that, estimating accurately the long-term growth of human population geologically, as regards food and the necessities of life, the expansion of plant and animals comprising it, must inevitably increase with greater force and speed, expressing a *more rapid* rate of reproduction, than that of the population. It's necessary to always have this correction in mind. Historically, it is only the irrational elements in our social system that make it difficult to clearly observe the effect of this natural phenomenon.[4]

Man is capable of creative thought, said Vernadsky. And thanks to this capability, he succeeded in developing in the material world around him new sources of energy, the latest example of which, in Vernadsky's day, was atomic energy. Because of this unique noetic capability, man succeeds in moving to energy sources ever more potent, ever more dense, from fire, to coal, to oil, to nuclear. The development of man is characterized, therefore, by increasing energy-density, or more specifically, energy-flux density. Because of this creative ability, man, in contrast to all other species, was not facing limits to growth, but was capable of continually



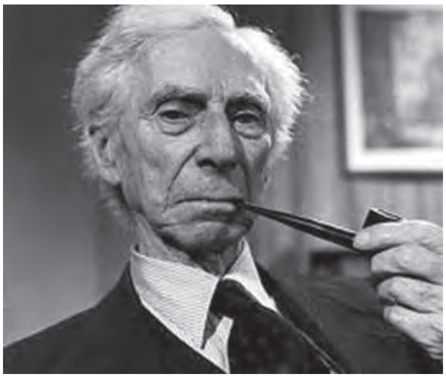
Hutchinson created the field of "population ecology" which treated man as simply another animal species.

4. Vernadskii, V.I., *Khimicheskoe stroenie biosfery zemli i ee okruzheniia. Nauka.* Moscow. 2001. p. 302. (emphasis added)

developing new resources which could support an ever-expanding population. Verandsky's rejection and unequivocal refutation of the arguments of Pastor Malthus early in his career was no aberration, as the Greenies would have it, but rather the hallmark of his fundamental philosophical and scientific outlook.

The Russellites

But Malthusianism was something of an endemic philosophy for the British Empire, dedicated to the preservation of its hegemony over world political and economic developments, and was widespread at places like Cambridge and Oxford. One of the key representatives of the Malthusian viewpoint was Bertrand Russell, who touted himself a mathematician and philosopher. Never one to conceal his views, Russell was quite open about his genocidal policies. Writing in a 1954 article published in *Crux*, the journal of the Union of Catholic Students of Great Britain, entitled "Birth Control and World Problems," Russell explains his view:



Bertrand Russell's genocidal policies made him in the words of Lyndon LaRouche "the most evil man of the century."

> Opponents of birth control make much of possible improvements in agricultural production either by new methods or by irrigation of deserts. What they refuse to face is that there is a limit to what can be done in this way, whereas there is no limit to the increase of geometrical progression. If the population of the world were to continue to increase at a constant rate, however slow, there would in time be only standing room, and no land whatever would be left for food production. Sooner or later therefore the increase of population must cease. Shall the cessation be brought about by war, by pestilence, or by starvation? No other possibility exists for the opponents of birth control—unless indeed, they were to advocate large-scale sterilization, which they find even more abhorrent.

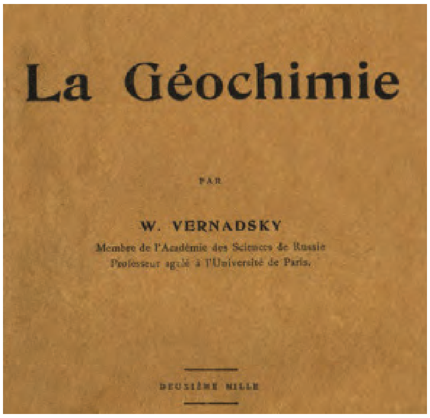
Later, Russell (an early proponent of nuclear war against the Soviet Union) and his circles would help to spread the virus of his misanthropic world-view to an entire generation of Soviet scientists under the aegis of such "collaborative" "scientific" organizations such as the Pugwash Conferences and the International Institute for Applied Systems Analysis (IIASA) in Laxenburg, Austria. Russell would utilize the danger of "nuclear winter" in order to brainwash scientists about the need for a no-growth, "green" agenda. While Vernadsky was not alive when Russell wrote that particular tract, he was quite aware of the general nature of Russell, who during the 30s was touting himself as an interpreter of the "philosophical implications" of Einstein's relativity theory. Writing in his diary in 1938 with regard to A.E. Fersman, a protégé and collaborator, whom he often chided for his lack of political courage, Vernadsky commented: "A.E. belongs to that type of scientist who feels *his* view of nature is so great, that he does not notice the paltriness of that 'view' when juxtaposed to the real greatness of nature itself, like B. Russell."

But Russell's views were rather mainstream for British intellectuals of an "imperial" outlook. And G. Evelyn Hutchinson was a man of the same mold. So at Yale, something happened to the project of publishing Vernadsky's works in English. Hutchinson was given a major role in the editing of Vernadsky's writings. Hutchinson created a field of dubious scientific worth called "population ecology" or "mathematical ecology." While his scientific work in that field was largely directed toward the populations of animal species, he, like Darwin, extrapolated his findings in the animal world to the world of man, warning that limits must be imposed on the growth of the human population. His "niche theory" of evolution described how each species, including man had to find its "niches" in this world of competition for Lebensraum and resources. Sadly, however, each species was relegated to its own particular "niche," beyond which it could no longer progress. As a professor at Yale, Hutchinson would go on to create a whole gaggle of ecology freaks, including biologist E.O. Wilson, Thomas Lovejoy of the World Wildlife Foundation, and many, many others. Because of his widespread influence, Hutchinson is characterized as the "father of ecology," although he himself attributed that title rather to Charles Darwin.

The Fraud

Already during his time at Yale in the 1930s, Hutchinson had learned of the work of Vernadsky, probably from his friend and colleague Alexander Petrunkevich. While Hutchinson didn't know any Russian, he had obtained a copy of the 1929 French edition of Vernadsky's *The Biosphere* and had his students read sections of it in his class. Hutchinson saw the possibility of using aspects of Vernadsky's work for his own purposes while suppressing Vernadsky's own world-view. Given Hutchinson's reductionist view of man, Vernadsky's idea of the noösphere and the role of human creativity in overcoming "limits to growth," even reflected in the more focused monograph, *The Biosphere*, was absolutely anathema to him.

Hutchinson had studied limnology at Cambridge during the post-World War I period in England, where the eugenicist movement was having its heyday. Evelyn imbibed his zero-growth philosophy literally from mother's milk. His mother, Evaline, a radical feminist, was an early adherent of sex psychologist Havelock Ellis, and a close friend of eugenics matron, Margaret Sanger, who fled to England from the United States to find more fertile ground for her anti-human philosophy.



Vernadsky's lectures on geochemistry at the Sorbonne were published in French in 1924.

The Hutchinsons were an integral part of the Cambridge social circle, which included the Darwins, the Huxleys, the Batesons and the Haldanes. At Cambridge, Hutchinson would strike up a close relationship with J.B. Haldane, who would later provide the backing of Western science for the checkered career of Alexander Oparin, the chief antagonist of Vladimir Vernadsky's views in post-war Russia.[5] Here he also struck up a friendship with Gregory Bateson, with whom he would collaborate at Yale in laying the basis for the counter-culture movement of the 1960s. When Bateson hooked up with the American social anthropologist Margaret Mead, Hutchinson would also become her friend and mentor, and in fact, her copy editor. Hutchinson was also close to British author and radical feminist, Rebecca West, who was for a time the wife of H.G. Wells.

Hutchinson received a professorship at Yale in 1928 and Yale would ever remain the lair from which he would spin his web of deviltry and deceit. He also served, together with Mead, on the staff of the American Museum of Natural History in New York. Hutchinson, Mead, and Bateson, as well as cultural anthropologist Ruth Benedict, would all participate in the conferences organized by the Josiah Macy Foundation in 1946, which were instrumental in creating the basis for the "alternative lifestyles" that would be foisted on America in the latter part of the 1960s, in the aftermath of the assassination of President Kennedy.

Editing Vernadsky

It was undoubtedly his connection with Petrunkevitch that brought Hutchinson into a position to influence the Vernadsky "legacy" in the U.S. Hutchinson, now retooling himself from limnology, the study of lakes, to biochemistry, was, because of his "expertise" in the field, given the task of editing George Vernadsky's translation of two of his father's papers in a series Vernadsky labeled "Problems of Biogeochemistry." Although George Vernadsky had translated both of these papers, Hutchinson would only publish the second of the two, and this heavily expurgated, in the *Transactions of the Connecticut Academy of Arts and Sciences* in June 1943. Hutchinson had thus begun a project of introducing an "expurgated" Vernadsky to the American public for the purposes of promoting his own genocidal agenda.

And what was Hutchinson's agenda? In December 1948, Hutchinson published a paper in *Scientific Monthly* entitled "On Living In the Biosphere." While he did not on this occasion try to drag in the name of Vernadsky, he clearly is starting to pave the way in that direction:

> Looking at man from a strictly geochemical standpoint, his most striking character is that he demands so much—not merely thirty or forty elements for physiological activity, but nearly all the others for cultural activity… We find man scurrying about the planet looking for places where certain substances are abundant; then removing them elsewhere, often producing local artificial concentrations far greater than are known in nature. Modern man, then, is a very effective agent of zoogenous erosion, but the erosion is highly specific, affecting most powerfully arable soils, forests, accessible mineral deposits, and other parts of the biosphere which provide the things that *Homo sapiens* as a mammal and as an educatable social organism needs or thinks he needs. The process is continuously increasing in intensity, as populations expand and as the most easily eroded loci have added their quotas to the air, the garbage can, the city dump, and the sea.

Elsewhere in the same paper he writes:

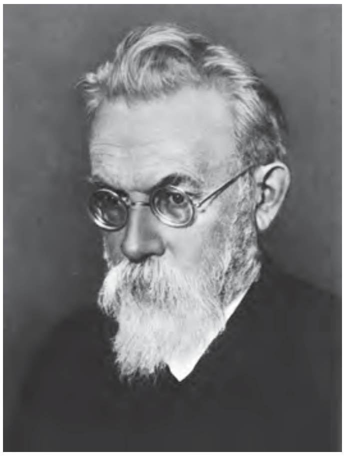
> The population of the world is increasing, its available resources are dwindling. Apart from the ordinary biological processes involved in producing population saturation already known to Malthus, the current disharmony is accentuated by the effect of medical science, which has decreased death rates without altering birth rates, and by modern wars, which one may suspect put greater drains on resources than on populations. Terrible as these conclusions must appear, they have to be faced.

5. See article by Meghan Rouillard, "A.I. Oparin: Fraud, Fallacy, or Both?" *21st Century Science & Technology*, Spring 2013.

The whole Russellite program is concisely presented in these remarks. To bring Vernadsky into this mix required some serious elisions in the written record.

In the paper published in the *Transactions*, Hutchinson eliminated entirely Vernadsky's first paper in the series "Problems of Biogeochemistry," on the pretext that "its propositions have become well-known through the other writings of the author (Vernadsky) and of his students, and there is no need of a translation at the present time." This was quite a remarkable statement given that almost none of Vernadsky's works had then (June 1944) been published in English.[6] Hutchinson readily admits with regard to the second paper that "some abridgement has been found desirable for the sake of clarity, but it is believed that all the ideas set forth in the original have been preserved in the present text." Fat chance that that will happen!

Vernadsky, who knew of Hutchinson through his work on limnology and through his son's and Petrunkevitch's letters, was excited by the fact that his paper would be published in the United States. He was following the project closely through correspondence with George and expressed gratitude to Hutchinson for taking it on. But getting the final copy, he was somewhat taken aback by some of the cuts made by Hutchinson. Writing to George on September 15, 1944, Vernadsky expressed his concern:



Vernadsky's entire philosophical outlook was imbued with the knowledge that the mind of man was a new and powerful geological force in the universe.

> I'm very grateful to you and Hutchinson. I'm just not in agreement with the omission on page 502 of the reference to Dana [geologist James Dwight Dana], who established the empirical generalization of the role of the central nervous system in the course of geological time. The power of the central nervous system increased by leaps and bounds. You can observe this in any paleontology textbook.
>
> It's funny that when I was working on this question in Moscow, I found at the Moscow University, after many years, American journals in which Dana defended himself against the theologians.

While Dana at a late stage in his career accepted the basic idea of evolution, he believed (unlike Darwin) that the process of evolution had a directionality to it, leading to the development of man and characterized biologically, as Vernadsky notes, by the development of the central nervous system. Dana, like Vernadsky, held that evolution had a directionality culminating in man in an epoch characterized chiefly by man's mental activity, which Vernadsky called the *noösphere* and Dana *cephalization*.

This was by no means the only cut that Hutchinson had made in the Vernadsky paper. He effectively eliminated almost all discussion of Vernadsky's seminal remarks on the work of Louis Pasteur on chirality and Vernadsky's idea of different "states of space."[7] Not unexpectedly, Hutchinson also eliminated portions of the manuscript in which Vernadsky expressed his unlimited confidence in the continuous progress of man's development through his creations of new ideas leading to technological advances. What remained was only a thin carcass of the real Vernadsky.

Soon afterward, in January 1945, Vernadsky's "Notes on the Noösphere" were published in *American Scientist* without such elisions. It is probable that George, who was sincerely intent on publishing his father's work in the United States and was aware of his father's concerns about the first translation, made sure that Hutchinson did not take a scalpel to this important statement. The "Notes on the Noösphere" also contains an extensive reference to the work of James Dwight Dana.

Creating a Green Movement

Of course, in 1944, it was an uphill climb in the United States, indeed, in the world at large, to introduce the notion of the genocidal population reduction program. The Second World War had done that all too effectively. "Population control" had been pretty much discredited by the Nazi program. And in the United States as elsewhere, there was a strong belief in the notion of scientific progress, similar to the belief so beautifully expressed in Vladimir Ivanovich's work at the time, specifically in his 1938 *Scientific Thought As A Planetary Phenomenon*. It would take a few decades before humanity would be prepared to accept these specious arguments in favor of its own demise.

The opportunity for introducing this "paradigm shift" in American society came in the 1960s. The brutal assassination of President John F. Kennedy and the initiation

6. The entire text of "Problems of Biogeochemistry, Part II" was published in English by *21st Century Science & Technology* (Winter 2000–2001). "Problems of Biogeochemistry, Part I" was also published by *21st Century Science & Technology* (Winter 2005–2006), utilizing the English manuscript copy of the text translated by George Vernadsky, and discovered in the Bakhmeteff Archives at Columbia University.

7. See article on Louis Pasteur, this issue, and Vladimir I. Vernadsky, "On the States of Physical Space" *21st Century Science & Technology*, Winter 2007–2008.

The brutal assassination of President John F. Kennedy was a decisive transformation of American culture away from its traditional notion of progress.

by President Johnson of that "long war in Asia" helped to plunge an entire generation of young people into a frantic search for "alternative life-styles." This was chiefly characterized by the hippie movement and its "back to nature" outlook. Here was an ideal opportunity to introduce on a broad scale those zero-growth ideas which had been anathema to an earlier generation.

In 1970, the "mainstream" scientific journal *Scientific American* devoted an entire issue to the theme of "The Biosphere." The introductory article was by none other than G. Evelyn Hutchinson. While he had not inserted Vernadsky's name in his 1947 diatribe, he would place it firmly in the center of this new effort to create a Green zero-growth movement. "The concept [of the biosphere] played little part in scientific thought," Hutchinson writes in his *Scientific American* piece, "until the publication, first in Russian in 1926 and later in French in 1929 (under the title *La Biosphère*), of two lectures by the Russian mineralogist Vladimir Ivanovitch Vernadsky. It is essentially Vernadsky's concept of the biosphere, developed about 50 years after [Eduard] Suess wrote, that we accept today."

The other articles in the magazine, dealing with the carbon cycle, the oxygen cycle, the nitrogen cycle, the role of agriculture, while written by different people, were also centered around the theme struck by Hutchinson: The activity of man on the planet is creating an ecological disaster and must therefore be limited.

Hutchinson, of course, could not completely eradicate Vernadsky's concept of the noösphere, so he simply asserted that Vernadsky had been mistaken in his view of human development. At the end of his article, Hutchinson writes:

> Vernadsky, the founder of modern biogeochemistry, was a Russian liberal who grew up in the 19th century. Accepting the Russian Revolution, he did much of his work after 1917, although his numerous philosophic references were far from Marxist. Just before his death on January 6, 1945, he wrote his friend and former student Alexander Petrunkevitch: "I look forward with great optimism. I think that we undergo not only a historical, but a planetary change as well. We live in a transition to the noösphere."
>
> By noösphere, Vernadsky meant the envelope of mind that was to supersede the biosphere, the envelope of life. Unfortunately the quarter-century since those words were written has shown how mindless most of the changes wrought by man on the biosphere have been. Nonetheless, Vernadsky's transition in its deepest sense is the only alternative to man's cutting his life-time short by millions of years. The succeeding articles in this issue of *Scientific American* may contain useful hints as to how this alternative may be brought about.

Two years later, in 1972, a newly constituted Club of Rome issued a report called *The Limits To Growth,* which depicted an even more drastic scenario. The report was published by the UN Commission on Environment and Development. The Russellite agenda was thus introduced at the highest level of government. And now there was a mass movement of disenchanted youth around which to organize for this genocidal program.

And Vladimir Ivanovich Vernadsky was made into a guru of this new movement as well. New Age geologist and entrepreneur John Allen, who was spending his time in the early 1960s in San Francisco's hippie stronghold, Haight-Ashbury, with beat poet William Burroughs and others of his ilk, came across a book by Hutchinson entitled *The Ecological Theater and Evolutionary Play,* which also referenced the work of Vernadsky. Allen quickly placed Hutchinson's Vernadsky on the banner of a series of half-baked projects, beginning with a hippie commune in New Mexico, called Synergy Ranch, and later an upscale and alleged high-tech version of the commune, called Biosphere II, which he marketed as a predecessor to space colonization. Allen even succeeded in convincing some people from NASA, who had been bitten by the Green bug, as well as a number of otherwise serious scientists from Russia, that his up-scale hippy commune was the wave of the future in space exploration. Synergy Press also published the first

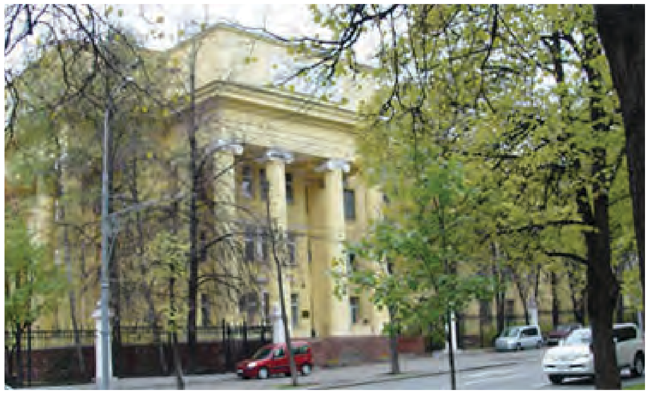
This Biosphere edition of the mainstream Scientific American was the first "shot across the bow" by the Greenie movement.

English translation of Vernadsky's *The Biosphere*—needless to say, in a heavily redacted edition.

James Lovelock, the so-called father of "climate change," with his thesis of Mother Earth, or Gaia, to whom mankind must bow in submission, also began to reference Vernadsky as his predecessor, even though he had no knowledge of Vernadsky before the 1980s.

As a result, to the extent Vladimir Ivanovich Vernadsky is known at all in the United States, he is widely seen in the form of Hutchinson's "ecological guru." *21st Century Science & Technology* and *Executive Intelligence Review,* both associated with the American statesman and economist Lyndon LaRouche, have taken upon themselves the task of introducing the real Vernadsky to the American public, to the American science community, and particularly, to the younger generation of Americans.

Vernadsky was one of the giants of science during the last century, a man whose ideas were often far ahead of his times. And science progresses by standing on the shoulders of its giants. Now when mankind is faced with the major scientific task of developing the new energy resources needed to support our growing population and of developing techniques here on Earth and in cosmic space for detecting and thwarting the threats that may face us from that region, as witnessed by the recent meteorite over Chelyabinsk, the thought—and spirit—of Vernadsky is more important than ever. By introducing the full depth of his scientific and philosophical achievements in the English language, we hope to provide American scientists with that giant, on whose shoulders they might stand from which to see a way forward for mankind, now enmired, in the worst financial crisis in history. Perhaps the optimism exhibited so strongly by Vernadsky, even in periods of repression and world war, may help to mobilize people today to begin to institute those needed changes which will enable mankind to launch a new era of growth and development in the "noösphere," and to help free a generation from that deadly mental illness known as "environmentalism."



Vernadsky Institute of Geochemistry and Analytical Chemistry

The Biogeochemical Laboratory founded by Vernadsky in 1929 now stands as the Vernadsky Institute of Geochemistry and Analytical Chemistry.

Human Autotrophy

by Vladimir I. Vernadsky

translated from the French by Christine Craig

Translator's Introduction:

Paris held a special place in Vladimir Vernadsky's heart, and he visited it numerous times over the course of his scientific career. His longest stay in Paris was from 1922-1925, the time during which this article was written for the Revue générale des sciences pures et appliquées *(1925) in France.*

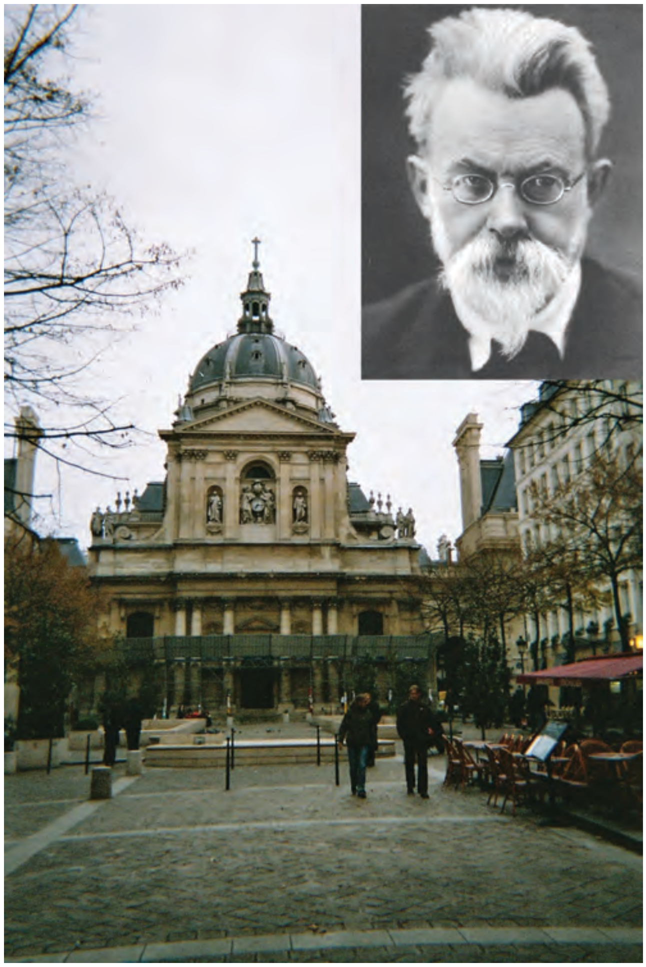
It was during this stay that Vernadsky began developing his concept of the noösphere. During this time period he also wrote his book Biosphere, *which he published in Russian in 1926 after returning to Russia.*

In Paris Vernadsky rubbed shoulders, not only with the French (and European) intelligentsia, but with many Russian émigrés who had fled the chaos of the Russian Revolution and its aftermath. The city, with its wealth of scientific and cultural institutions, was incredibly fertile ground for the growth of scientific and social ideas. It was here that the very word noösphere was coined, perhaps by Édouard Le Roy, or maybe Teilhard de Chardin, probably in response to having sat in on Vernadsky's lectures at the Sorbonne. Here, on the Left Bank of the Seine River, the Curies, Pierre and Marie were ensconced at the Radium Institute, while Louis Pasteur lay buried in a vault beneath his Pasteur Institute a few miles away.

Vernadsky had the opportunity to teach for several terms at the Sorbonne (founded in the 13th century), and these lectures may have formed the foundation of his Biosphere. *They no doubt also shaped the ideas he expounds in the present article, where he broaches the subject of the noösphere (a word he does not yet use) in a unique way, by focusing on the idea of human autotrophy: mankind, through scientific advances, freeing himself from reliance on the "ancient material forms of existence," to become "a third branch independent of living matter," along with chemoautotrophs and photoautotrophs.*[1]

I was inspired to translate this work after reading it in the (now-defunct) French magazine Fusion, *Jan.-Feb. 2006. Footnotes, unless indicated as Vernadsky's, are mine.*

1. For a fascinating essay on Vernadsky in Paris, please read "Why to Paris," by A. V. Lapo, 2002. URL: http://vernadsky.name/wp-content/uploads/2013/02/Lapo-Pochemu-Parizh-angl.pdf



Sorbonne: Wikipedia user Melusin, Vernadsky: T.B. Pyatibratova, Tambov State Technical University

1 There exists now on the terrestrial surface a great geological force, perhaps cosmic—although planetary action is not generally taken into consideration in concepts of the cosmos, in scientific ideas or those based on science.

This force does not seem to be a new manifestation or special form of energy, nor yet a pure and simple expression of known energy. But it exerts a profound and powerful influence on the course of energetic phenomena on the Earth's surface, and consequently has repercussions, smaller but undeniable, beyond the surface, on the existence of the planet itself.

This force is human reason, the directed and controlled will of social man.

Its manifestation in the environment over the course of myriads of centuries is apparent as one of the expressions of the totality of organisms "of living matter"[2]—of which humanity constitutes but one part.

However over the last several centuries, human society has increasingly distinguished itself from [merely] living matter, by society's action on the surrounding environment. This society becomes in the biosphere, that is to say in the outer envelope of our planet, a unique factor, growing powerfully with great acceleration, a factor which changes—by itself—in a new and rapidly growing manner, the most fundamental mechanisms of the biosphere.

It becomes more and more independent of other forms of life and evolves toward a new vital manifestation.

2 Certainly man seems inseparably tied to living matter—to the entirety of organisms which now exist or which existed before him.

He is linked primarily by his genesis.

No matter how remotely we push into the past, we are sure to find living generations, which are without any doubt genetically linked with each other.

In this past, we can discover with certainty more than ten thousand successive generations, at least—father to son—of *Homo sapiens*, which in their essence cannot be distinguished from us, neither by their character, nor by their exterior, nor by their elevation of thought, nor by the force of their emotions, nor by the intensity of their spiritual life. More than 200 generations have already passed since the era of the birth within human society of the great constructs of religion, science, and philosophy. More hundreds of generations separate us from the times when were laid out the first broad outlines of the works of art, music, myths, magic, which gave birth to religion, to science, and to philosophy.

Francesco Redi (1621-1697)

But the origins of man must be sought even further back in the depths of time. Those ancestors are lost in the mists of the unknown. Their form, their organism, were different than ours; but the essential fact—the succession of generations linked materially, father to son—remains intact. Our connections with these beings so unlike us are concrete. Their past existence is not a fiction.

As far back as our thought or our scientific researches are able to reach into the geological past of the Earth, we encounter the same phenomenon of the existence on the terrestrial crust of one single block of life,[3] uninterrupted, unique. We observe life which is extinguished and renews itself eternally.

About 100 generations have passed since the thinking of the great Greeks focused on this phenomenon, which produced among them the effect of a profound cosmic mystery. It remains for us, their remote descendents, just as it stood before these wise men.

About ten generations before us, the great Florentine naturalist F. Redi—the doctor, poet, man of high morals, a great Catholic Christian—had first expressed a new idea which probably had, from time to time, sprung up in isolated thinkers of past generations, but remained hidden. This revolutionary idea was expressed without, however, coming to the attention of his contemporaries. Their mentality was evidently little prepared. Redi affirmed: All living organisms draw their origins from other living organisms—formally expressed in this form one or two generations after him, by another Italian naturalist, A. Vallisnieri.

This principle of F. Redi was not incorporated into our scientific concepts until the 19th century, almost eight generations after his death. It was a great Frenchman, L. Pasteur, a man of kindred spirit, soulmate of F. Redi, who introduced it definitively into our representation of the cosmos.

Certainly one must represent the genealogy of humankind by the millions of successive generations of beings, which follow, father to son without interruption, and wherein the morphology and functions become modified from time to time. Furthermore, it is extremely likely that life was quite brief for our long-gone ancestors. In measuring the past through the successive generations of man and his ancestors, we arrive at vast numbers surpassing our imagination.

3 Western man has followed the clear path of reason of F. Redi and L. Pasteur, only with reluctance and great effort.

Ideas relating to the eternity of life, to its lack of be-

2. On the notion of "living matter" as a group of organisms, see V. Vernadsky: Geochemistry, Paris, Félix Alcan, 1924, p.51. I give in this book a more detailed view of some problems relating to the subject of this article (author's footnote).

3. Throughout his article, Vernadsky used the terms *bloc de la vie* and *bloc vivant* (block of life and living block) to indicate the totality of organisms as a group under consideration. This is different from the concept of "life" in itself. I have translated his terms in various ways throughout the translation, while trying to remain faithful to his meaning.

ginning, to the insurmountable difference which exists within the framework of known physical-chemical phenomena, between inanimate matter and living matter, have been in radical discord with his [Western man's] thought-habits, with his worldview. Ideas relating to the beginning and the end of the visible cosmos, of the material universe, as well as to the true unity of all that exists, have profoundly molded his mind.

Oftentimes abiogenesis, that is to say, the genesis of living organisms from inanimate matter without another organism as intermediary, seems logical to the learned; it seems to be a necessary idea for the history of geology and of our planet, and for the scientific explanation of life. They have expressed—with a profound faith—the conviction that the direct synthesis of organisms from scratch out of the material elements will be the inevitable culmination of scientific progress. They don't doubt that there was a moment—if the process follows its course not just in our era—where an organism sprang from the terrestrial crust by a spontaneous change of inanimate matter.

It is necessary to not lose sight of the fact that these conceptions have their root not in the notions of science, but in the domain of religion and philosophy.

Certainly it is *possible* that these conceptions correspond to reality. They cannot yet be considered as refuted by science. But nothing indicates their likelihood. There is nothing to indicate that the problem of abiogenesis is not of the same class as the problems of the quadrature of the circle, the trisection of the angle [by compass and straightedge], perpetual motion, and the philosopher's stone. The inclination of thought to solve these problems has had very important effects. Thanks to it great discoveries have been made—but still the problems are not solvable in the real world.

In order to remain in the domain of science we must declare that:

1. Nowhere have indications of abiogenesis been found in the phenomena which take place or have taken place on the terrestrial crust.

2. Life, such as it presents itself to us in its manifestations and variety, has existed without interruption since the formation of the most ancient geological layers—since the Archean Epoch.

3. Not a single organism exists—among the hundreds of thousands of different species studied—which was not ordered in its genesis exclusively by the principle of F. Redi.

If abiogenesis is not a fiction of the mind, it is only produced outside of known physical-chemical phenomena. Only the discovery of unforeseen phenomena would be able to demonstrate its reality, like the discovery of radioactivity had proved the mass defect in matter and the destruction of the atom, which were only manifested outside of the physical-chemical phenomena studied up until then.

At the present time we are not able to scientifically consider life on our globe otherwise than as an expression of a unique phenomenon which has endured without interruption since the most remote geological times whose clues we have been able to study. Living matter has endured throughout all this time separated from inanimate matter. Man is irrevocably linked to the same totality of life with all the living beings which exist or which have existed.

4 Man is also linked to this totality by his nutrition. This new connection, as intimate and as indispensable as it is, is not of the same order as the uninterrupted succession of the generations of living beings. This connection doesn't appear to us as a profound natural process, immutable, indispensable to life like that which is expressed by the Redi principle.

It is true that this connection is part of a great geochemical phenomenon—of the circulation of the chemical elements in the biosphere because of the nutrition of organized beings. This connection has perhaps changed, yet without affecting the stabilty of the totality of life. In the paleontological history of the biosphere, there are serious indications of an analogous shift which had already taken place in the course of time, in the evolution of certain groups of bacteria—invisible and minute beings, but with strong geochemical power.

Man's dependence on the living for his nutrition presently rules all of his existence. A change in regime, were it to come, would have immense consequences. The crucial fact, at the present moment, is the potential which is proper for man to preserve his existence, to construct and keep intact his unique body through the assimilation, either of other organisms, or of products of their life. The chemical compounds thus formed in the terrestrial crust are necessary and indispensable for existence, but the human organism does not have the means to produce them himself. He must look for them in his living environment, annihilating other living beings or exploiting their biochemical work. He dies if he finds himself upon the terrestrial surface in the absence of other living beings, which constitute his nourishment.

It is clear that all human life, all societies developed in the course of history, are controlled by this necessity. In the last analysis, it is this irresistible need which governs the human world, which shapes all of its history and all of its existence.

It is famine, in the end, which is the pitiless factor, the terrible agent of the social edifice. Social equilibrium is only achieved by incessant labor, and it is always unstable. The great disruptions of society, the crimes perpetrated on this terrain always have disastrous consequences.

Our civilization in this respect finds itself always at the brink of a precipice. At present hundreds of thousands of men die or languish in Russia because of lack of nourishment and millions of others—more than 10-15 millions—have been victims of social wrongs. Never has the precariousness of human existence been so clear and the specter of disgrace and decadence so alive in the spirit of disorder.

5 Only recently—less than five generations separate us from those times—has man begun to understand the intricate and very special structure of the living system in which he appears.

And as yet the consequences of this structure—enormous social and political consequences—have not penetrated his thought.

One can see this plainly in considering current social ideas that are promulgated around us and which set the world into motion. These ideas reside fundamentally outside of today's science. They are the expression of the past in the exact sciences, corresponding to the science of one hundred years ago! All the progress in science of the 19th- and 20th centuries have had but a feeble influence on contemporary social thought. The exact sciences have been transformed from the bottom up and their antagonism with social ideas has become greater and greater. Not just the masses—but those who lead and inspire as well—belong in their thinking and their scientific baggage to a long-past stage of scientific evolution. Humanity, in its actual social development is in large part governed by ideas which conform little to reality and express the scientific thinking and knowledge of vanished generations of the past.

A profound change of social and political ideas, because of fundamental new acquisitions in natural science, in the exact sciences, is imminent, and it is already making an appearance. The problems of nutrition and of production must be reexamined. This change will necessarily be followed by an upheaval in the very social principles which direct opinion. The slow infiltration of scientific acquisitions into life and into thought is a habitual and general trait in the history of science.

6 The new foundations of our present representation of nutrition were achieved in the years before the end of the 18th century by the efforts of a small elite of humanity who transformed our conception of the world without having been understood or valued by their contemporaries.

They were, first, Lord H. Cavendish of London, the richest man in his country, misanthrope and ascetic of science; A. L. Lavoisier, financier and experimentalist, a profound and lucid thinker, whose assassination is an indelible shame for humanity; the ardent theologian and radical Englishman J. Priestly, persecuted and misunderstood, who by luck escaped death when the mob burned and destroyed his house, his laboratory, and his manuscripts, and who had to flee his country; the Genevese aristocrat, representative of a family where high scientific culture was hereditary, Th. de Saussure; the profound Dutch naturalist and doctor J. Ingen-Housz who, because he was Catholic, could not make a career in his country and worked in Vienna and England.... They were followed by many researchers in all countries.

Wilhelm Pfeffer, German plant physiologist (1845-1920)

One or two generations after these pioneers—around 1840—their thinking had definitely penetrated science and was expressed lucidly and fully in Paris by J. Boussaingault and J. Dumas, and at Giessen in Germany by J. Liebig.

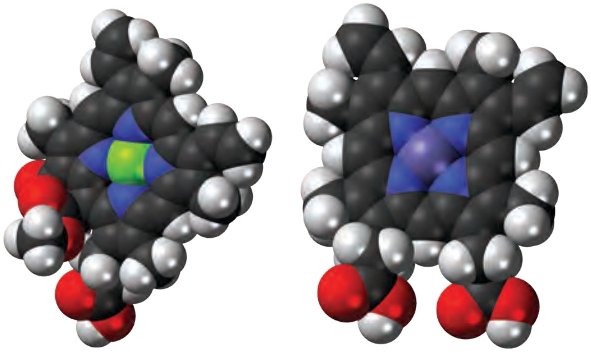
A major effect of immense impetus was unleashed by this labor.

7 The living system—the world of organisms—seems *double* in function and position in the crust.

The greater part of living matter, the world of green plants, depending only on inanimate matter, is independent of other organisms. The green plants are able to create for themselves the necessary substances for their life in utilizing the inorganic chemicals in the crust. They take the gasses and aqueous solutions from the surrounding environment and construct for themselves innumerable carbon and nitrogen compounds—hundreds of thousands of different substances—which are incorporated into the composition of their tissues.

German physiologist W.[4] Pfeffer distinguished organisms which possess these abilities by the name of *autotrophic organisms*, because they were only dependent on themselves for their nutrition. He named *heterotrophic*

4. Vernadsky mistakenly had Pfeffer's first initial as J., but is clearly referring to the great German pioneer in plant physiology, Wilhelm Pfeffer.

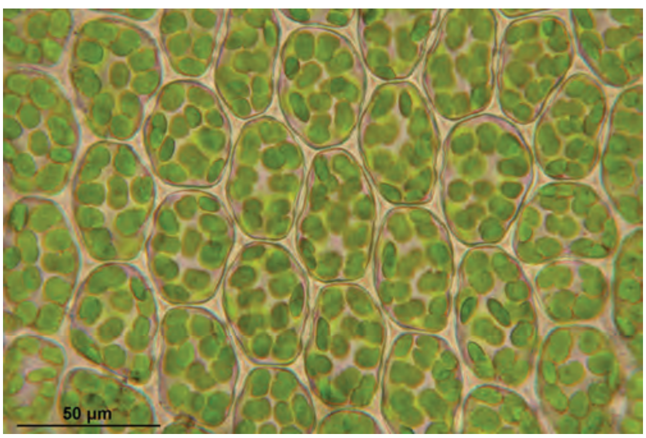


Three-dimensional space-filling images of the porphyrin molecule common to both chlorophyll and hemoglobin. On the left is the chlorophyll-a porphyrin molecule with its magnesium center. On the right is the heme porphyrin molecule with its iron center.

those organisms which depended, for their nutrition, on other organisms, utilizing their chemical products. They are able only to change chemical compounds made outside themselves, which they appropriate for their life, but cannot construct for themselves.

There exist green organisms whose nutrition is mixed, organisms which in part make the necessary chemical compounds, and use the substances of inanimate matter, and in part obtain it—as with parasites—by exploiting other organisms. These beings, numerous in living nature, are the *mixotrophs* of Pfeffer. Mistletoe is a well-known example.

In the final analysis autotrophic green organisms—green plants—form the foundation for the living system. The world as diverse as the mushrooms, the millions of animal species, humankind—cannot exist except as a consequence of their biochemical work. This work would not be possible except by the grace of the innate property of these organisms to transform the energy of solar radiation to chemical free energy.



wikimedia: Hermann Schachner

Cells of the moss Plagiomnium affine *showing numerous plastids per* cell.

It is clear that life is not a simple terrestrial phenomenon, but manifests itself as a cosmic phenomenon in the history of our planet, in so far as the principle of Redi corresponds to reality.

And furthermore it follows that the living system is not an assemblage of isolated individuals, an assemblage owing to chance, but exhibits a mechanism where the constituents have functions which influence and coordinate it.

8 Autotrophic green matter is able to perform its proper function in this mechanism thanks to its elaboration of a green substance with very specific and remarkable properties—*chlorophyll*. It is a complex compound which contains atoms of magnesium and has a molecular structure, containing carbon, oxygen, hydrogen, and nitrogen, that is quite similar to that of the red hemoglobin in our blood, where the magnesium is replaced by iron.

Chlorophyll, whose structure and chemical properties are beginning to become clear, is produced in plants within special tiny microscopic granules—the plastids—dispersed throughout the cells. These plastids only originate from the division of other plastids. The organism is unable to obtain them otherwise. This demonstrates a remarkable fact, which indicates a general phenomenon analogous to that expressed by F. Redi's principle. No matter how far we push back into the past—we see the formation of chlorophyllic plastids brought about exclusively by previously formed plastids.

Thanks to plastids of chlorophyll, the organism of green plants is able to pass down its life to other organisms.

If we only considered their nutrition—green plants would be able to exist alone on the surface of our planet.

9 The repercussion of the existence of autotrophic organisms with chlorophyllic function on the surface of the Earth is immense.

Not only is it they which give birth to all other organisms and humankind—but they regulate the chemistry of the terrestrial crust. One can get an idea of the magnitude of this phenomenon by recalling some numerical facts.

The verdure of our gardens, our fields, forests, and prairies surround us. Seen from another planet, from cosmic space, Earth would have a green tint. But that mass of chlorophyll represents but a part. The greatest portion of chlorophyll is invisible to us. It lies in the uppermost layers of the worldwide ocean at depths of up to approximately 400 meters. It is contained in innumerable myriads of unicellular, invisible algae each of which gives birth in the course of two or three daily rotations of our planet, to a new generation, which begins to reproduce itself. In this way, if they did not figure into the nutrition of other beings, their number would become prodigious and fill the worldwide ocean.[5]

The existence of free oxygen in our atmosphere and in the waters is the expression of the chlorophyllic function. All the free oxygen of the globe is a product of green plants. If green plants no longer existed, in a few hundreds of years there would not remain a trace of free oxygen on the surface of the Earth, and in the end chemical transformations would capture it all.[6]

The mass of free oxygen of the surface of the Earth corresponds to 1.5 quadrillion ($1x10^{15}$) metric tons. That number gives only an idea of the geochemical importance of life.

The amount of chlorophyll produced in green plants necessary to keep free oxygen at this level corresponds to many billions of tons at least, existing at each moment in the bodies of autotrophic plants.

S. N. Winogradsky, the Ukrainian-Russion microbiologist and soil scientist (1856-1953).

10 It has been more than thirty years since the Russian biologist S. N. Winogradsky introduced into this situation a new and important attribute which demonstrates the already-great complexity of the living system.

He discovered the existence of autotrophic living beings without chlorophyll. These are invisible beings, bacteria which teem in the soils, in the superficial parts of the crust, and penetrate the floor of the worldwide ocean.

Notwithstanding their smallness, thanks to their prodigious reproduction, their importance in the economy of nature is huge. This enormous reproduction—comparable with that of the unicellular green algae—obliges us to consider their existence as a phenomenon on the order of that of green plants.

Certainly the number of species of autotrophic bacteria is small, not more than a hundred, while that of green plants is close to 180,000. But whereas in a day each bacterium is able to engender many trillions of individuals, one green unicellular alga, which of all the green plants reproduces the most rapidly, cannot produce in the same interval of time but a few, and generally much less—say one sole individual in two or three days.[7]

The bacteria discovered by S. Winogradsky are independent in their nutrition not only of other organisms, but of solar radiation. In the construction of their bodies they use chemical energy from terrestrial chemical compounds—the minerals—rich in oxygen.

They produce by means of this decomposition—and by virtue of the syntheses which are their consequence—an immense geochemical work. Their role is very great in the history of carbon, sulfur, nitrogen, iron, manganese, and probably many other elements of our globe.

It is certain that they belong to the same life group as the other organisms, because they get their nutrition from these last and use their waste. We are led to think that the connection is very close, that they belong in this genetic group.

One can consider them as very specialized derivatives of green plants, as is done for non-chlorophyllic plants in general, yet without excluding the possibility of seeing in them representatives of the ancestors of chlorophyll-producing beings.

In our present state of knowledge, the first hypothesis seems most likely. Nevertheless, one must always take into account that these organisms of S. Winogradsky play a preponderant role in phenomena of the superficial modification of terrestrial minerals. These modifications seem to be immutable over the course of the geological history of our planet. They have not changed since the Archaic Era.

11 Man is a heterotrophic social animal. He can only exist in the presence of other organisms, especially green plants.

His existence on our planet is clearly distinguished all the same, from that of all the other organized beings. Reason, which distinguishes man within the assemblage of living matter, gives living matter remarkable characteristics, profoundly changing its [living matter's] action on the environment.

The genesis of man was a singular event, unique in geological history, which had no analog in the preceding myriads of centuries.

From the scientific standpoint, one must consider it as the consequence of a long natural process, of which the beginning is lost to us, but which has lasted without interruption over the course of all of geologic time. Until now, no scientific theory has been able to encompass the paleontological evolution of organized beings, of which the latest important expression has been the genesis of man.

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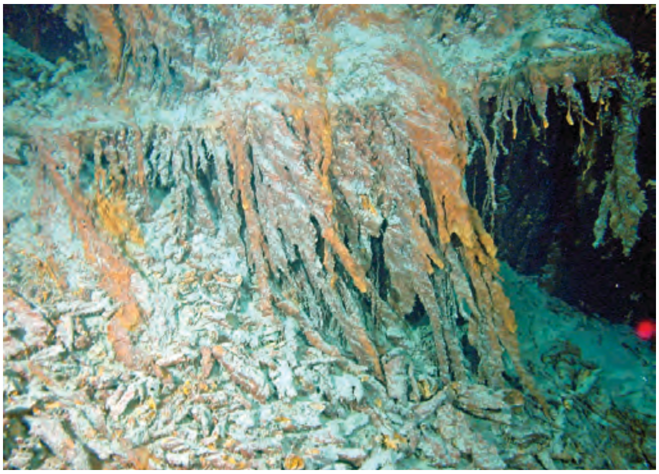
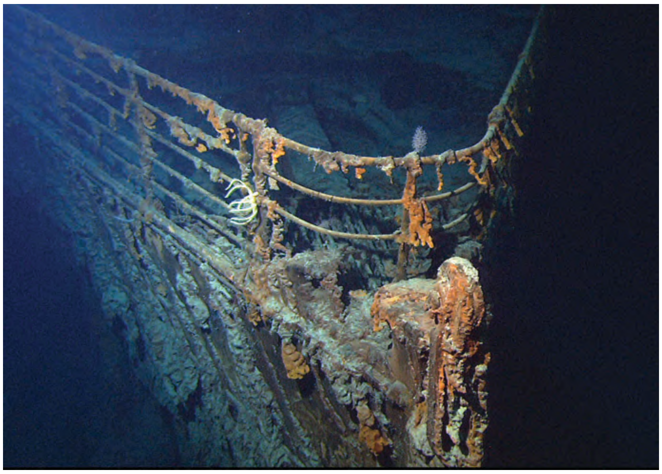
5. Most, but certainly not all of these "invisible algae" would now be placed among the prokaryotes as cyanobacteria.

6. This was written in 1925, and shows a clear understanding of the primary role of photoautotrophic organisms in the generation of the present atmosphere of Earth, which he addresses again in his *Biosphere*, published a year later.

7. If the chemoautotrophic bacterium divided once every half-hour, in 24 hours it would produce about 281.5 trillion individuals. If the eukaryotic unicellular alga divided once every 24 hours it would produce two individuals.

Left: Lori Johnston, RMS Titanic Expedition 2003, NOAA-OE, Right: Courtesy of NOAA/Institute for Exploration/University of Rhode Island (NOAA/IFE/URI)

"Rusticles" feasting on the largesse of the noösphere. These are consortia of bacteria and fungi enjoying a 100-year feast on the iron parts of the sunken Titanic 3.8 km beneath the ocean surface. Chemoautotrophs present in this living community are capable of deriving energy from oxidizing the iron deposited on the deep, dark, and oxygen-poor terrain of the ocean bottom after the RMS Titanic *sank.*

We are unable to represent the genetic change of the living system—the extinction and generation of innumerable species—except under an empirical generalization—that of the evolution of species.

For a man of science, the empirical generalization is the foundation of all knowledge, its form the most certain. But, to connect it to other facts and empirical generalizations, the learned man must avail himself of theories, axioms, models, hypotheses, abstractions. We have but an imperfect sketch in this domain.

It is clear that there exists a determined direction in the paleontological evolution of organized beings, and that the appearance of understanding, of reason, of coordinated will on the terrestrial surface—this manifestation of man—cannot be a game of chance. But it is impossible for us at present to give an explanation of this phenomenon, that is to say of the logical connection with our abstract scientific construct of the world—based on these models and these axioms.

12 Man is profoundly distinguished from the other organisms by his action on the environment. This distinction, which was great from the beginning, has become immense with the passage of time.

The action of other organisms is almost exclusively determined by their nutrition and their growth and increase. The sole fact of the formation of free oxygen is sufficient to appreciate the planetary importance of their nutrition. And it is one fact among thousands of others. The formation of coal, petroleum, iron-bearing minerals, humus, calcites, coral islands, are isolated cases—among thousands of others—of the manifestation of their increase.

Mankind certainly acts in the same way as all of these organisms. But his mass is completely negligible in comparison with the totality of living matter and the direct manifestations in living nature of his nutrition and his increase are almost nothing. The wise Austrian economist L. Brentano has given a very clear representation of the scale of humanity within the environment. If one assigns to each human individual a square meter, and if one brings together all the humans existing on the terrestrial surface—the surface that they would occupy would not exceed that of Lake Constance.[8]

It is clear that the manifestation of such a living mass considered on the scale of geological phenomena would be negligible.

Reason changes all. Through it, man utilizes material in the environment—inanimate or living—not only for the building of his body, but also for social life. And this usage has become a great geological force.

Thought, by its existence, introduces into the crustal mechanisms a powerful process having no analog before the appearance of man.

13 Man is the *Homo faber* of M. H. Bergson. He changes the aspect, the chemical and mineralogical composition of his living environment. His living environment is the whole of the surface of Earth.

His action becomes stronger and more coordinated with each passing century. The naturalist must acknowledge a natural process of the same order as all of the other geological manifestations. This process is necessarily regulated by the principle of inertia—it will follow its

8. Lake Constance, 571 km^2 in size, lies between Germany (Bavaria) and Switzerland at the foot of the Alps, and is fed by the Rhine River.

NASA Earth Observatory, Jesse Allen

A patchwork of farmland in northwest Minnesota along the Buffalo River

course regardless, if forces don't exist which oppose it or which take it to a potential state.

The discovery of agriculture, made over 600 generations before us, decided the path of humanity. By controlling the life of the autotrophic green organisms on the terrestrial surface man gained leverage, with immense consequences for the history of the planet. Man has become by this fact master of all living matter, and not just green plants, since the existence of all beings is controlled by the green plants. Little by little he changed living matter by the decisions—the goals—of his reason.

Through agriculture, he was liberated—in his nutrition—from the natural living environment, of which all the other organized beings are naught in this respect but impotent processes.

14 Relying on this great conquest, man has annihilated "virgin nature." He has introduced immense quantities of new, unknown chemical compounds and new forms of life—races of animal and plants.

He has changed the course of all of geochemical reactions. The face of the planet became new and found itself in a state of continual upheaval.

But man has not yet succeeded in gaining, in this new environment, the security necessary for his life.

In his social organization, existence itself, for the majority is precarious, the distribution of wealth does not give to the great mass of humanity the means of a life conforming to moral and religious ideals.

New, troubling events, which relate to the bases of his existence, are let loose in these recent times.

The reserves of natural resources decrease visibly. If their usage grows with the same force, the situation will become grave. In two generations one would detect a scarcity of iron; petroleum would also quickly become scarce; in a few generations, the question of coal would become tragic. It is the same for most of the other natural resources. The dearth of coal would be particularly grave, because it is coal which procures for man the energy necessary for society in its present form.

This is an inevitable phenomenon, because man uses the stores of natural resources which were formed throughout myriads of centuries and which could not be replenished except in the same length of time. These reserves are necessarily restricted. Similarly if one found other unknown sources, or if one used the less rich or deeper concentrations—one would only push back the date of the critical period—but the troubling problems would remain unresolved.

For generations, profound thinkers have perceived the necessity of radical social means, of scientific acquisitions of a new order to rein in the imminent danger. At the beginning of the last century, the imminent scarcity of natural resources was not yet perceived, because the energy at man's disposal in this era was still largely connected to ancient material forms of existence—to the life and works of men, of plants, and of animals. Nevertheless already the founders of socialism—particularly Count H. de Saint-Simon, W. Godwin, and R. Owen—understood the primary importance of science, the impossibility of resolving the social question while using only the resources which existed in their day, without augmenting, by science, the means of human power.

It was truly a scientific socialism in a sense which has since been forgotten.

The problem which is posed at this moment before humanity clearly goes beyond the social ideology, which has since been elaborated by the socialists and communists of all schools, who in their constructs have allowed the vivifying spirit of science—its social role—to elude them. Our generation has been victim of an application of this ideology in the course of tragic events in my country—one of the richest in natural resources—of which the results were death and famine for the multitude and economic failure of the communist system which seems undeniable. But the failure of socialism seems more profound. It presents in general the social problem from a too-restricted viewpoint, which does not correspond with reality; it remains superficial.

15 To resolve the social question it is necessary to plumb the foundations of human power—to change the form of nourishment and the sources of energy which man uses.

Precisely on these two points, little by little the thoughts of researchers are engaged. Here one is on solid ground. Not only can there be no doubt of the possibility of solving these two problems, but it is also clear that they will inevitably be solved in a very short time, even in comparison with the human lifespan.

The solution to these problems is taking shape as a result of scientific progress outside of all social preoccupation. After generations, science, in its quest for truth, is forced to discover new forms of energy in the world and great organic chemical syntheses. It labors with very insufficient means, the only ones available in human society today, where the situation is in striking contradiction with its [science's] real role as producer of wealth and of human power.

This scientific movement can be accelerated by creating new methods of research; it can't be stopped. Because there is not a force in the world which can shackle human understanding in its march, once it has understood, as in the present case, the scope of the truths which are opened before it.

16 Until now, the power of fire in its multiple forms was almost the sole source of energy for society. Man obtained it by the combustion of other organisms or their fossil remains.

Some decades ago, he began systematically to replace it by other sources of energy, independent of life—first by hydropower. The quantity of hydropower—the motive force of water—existing on the terrestrial surface was measured. And it was seen that, large as it seems, it is not sufficient by itself for societal requirements.

But the reserves of energy which are at the disposal of reason are inexhaustible. The force of the tides and ocean waves, radioactive atomic energy, solar heat are able to give us all the power needed.

The introduction of these forms of energy into life is a matter of time. It depends on problems whose solutions present nothing impossible.

The energy thus obtained will not have practical limits.

In directly utilizing the energy of the sun, man is made master of the source of energy of the green plant, of the form that he now uses through the intermediary of the latter in his nourishment and as fuel.

17 The synthesis of foodstuffs, freed from the intermediary of organized beings, when accomplished, will change human prospects.

It grips the imagination of the learned after the great successes of organic chemistry; in fact it presents a hidden but always vibrant aspiration of laboratories. It is never lost from view. If the great chemists only express it from time to time, like the able M. Berthelot, it is because they know that the problem will not be resolved before the undertaking of a long preliminary work. The work is carried out systematically, but must be the labor of many generations, considering the great poverty of science within our social structure.

One generation has already disappeared since the death of M. Berthelot. We are much closer to this supreme goal than we were during his lifetime. We can follow its slow but incessant progress. After the brilliant work of the German chemist E. Fischer and his school on the structure of albumin and of the carbohydrates, there can be no doubt of its eventual success.

During the Great War, the problem was often envisaged in various countries in its practical aspect and

Deviantart user Shefu-de-combinat

Ammonia processing by the Haber-Bosch process was one of the most significant steps toward human autotrophy in modern history. It can be argued that the synthesis of ammonia from atmospheric nitrogen and hydrogen without the required intervention of microorganisms, can be credited with enabling half of our 7 billion earthlings to be alive today. Furthermore, half the nitrogen present in the average human body today, came from Haber-Bosch ammonia, not from life-derived nitrogen-fixing processes. The green revolutions were fueled by Haber-Bosch nitrogen fixation, which is today fueled mainly by natural gas, but could be integrated into nuplexes using fourth-generation nuclear technology to boost this technology to the next level.

faith in its imminent solution took deep root among the learned.

Certainly it often happens that a scientific discovery is lost or doesn't find its practical application, its introduction into life, until long after it was first made. But we can be confident that the synthesis of food will not meet such a fate.

We await the discovery of this synthesis, and its great consequences to life will immediately be manifested.

18 What would be the significance of the synthetic production of nutriments to human life and to the life of the biosphere?

By its accomplishment man would free himself from living matter. From a social heterotrophic being, he would become an *autotroph*.

The repercussion of this phenomenon within the biosphere would be immense. It would signify the schism of the block of life, the creation of a third branch independent of living matter. By this feat there would appear on the terrestrial surface, and for the first time in the geological history of the globe, an *autotrophic animal*.

Today, it is difficult, perhaps impossible, for us to grasp the geological consequences of this event—but it is clear that it would be the culmination of a long paleontological evolution, which would represent, not an action of the free will of humanity, but the manifestation of a natural process.

By this achievement, human understanding would produce not only a great social effect, but a great geological phenomenon.

19 The repercussion of this synthesis in human society shall certainly touch us with ever-greater force. Will it bring good or will it bring new desolations to the human species? We don't know. But the course of phenomena—the future—will be perhaps controlled by our will and by our reason. We must prepare to understand the consequences of the actions of this inevitable discovery.

Only isolated thinkers sense the approach of this new age. They see these consequences differently.

One finds the expression of these intuitions in works of fiction. The future seems troubled and tragic for some (*Histoire de quatre ans*, by D. Halévy), at the same time that others see it as great and beautiful (*Auf zwei planeten*, from the profound German thinker and historian of ideas, K. Lasswitz).

The naturalist can only contemplate this discovery with a great tranquility.

He sees in its accomplishment the outcome of a grand natural process which has endured for millions of years and which gives no sign of dissipating. It is a creative process, and not anarchic.

Indeed, man's path is always formed in great part by man himself. The creation of a new autotrophic being will give him possibilities which have been lacking for the accomplishment of his secular moral aspirations; it will open for him the path to a better life.

V. Vernadsky
Member of the Russian Academy of Sciences
General Review of Pure and Applied Sciences, 1925.

What Is Life?

The Passionate Dedication of Louis Pasteur

by Denise Bouchard Ham and Roger Ham

Part I of II

A man of genius was needed to bring light in all this darkness. He was to be Pasteur. This man had the rare gift of insight.

You will grant, You will grant, ladies and gentlemen, that there are two ways for the human mind to gain knowledge—reason and imagination. In the modern world, dominated by technology, we are so accustomed to rational progress that we have come to hold imagination in too small esteem. And yet without it there could never be great inventors, any more than there could be great writers and great artists.

Imagination, in the scientific genius, assumes the special form of insight. This is the sudden intuition of a truth without the interposition of reasoning. Insight is what makes the scientists of genius foresee the end to be achieved. . .

What contradictory qualities he must possess! Besides the gift of observation, he must be endowed with imagination, so he must be a poet. . . he must not be narrowly specialized, his knowledge must range over widely varied fields. He must discipline himself to assiduous labor. . . He must confine himself within the bounds of rigorous experiment, requiring him to bridle his imagination. . .[1]

—Pasteur Vallery-Radot, Pasteur's grandson, at the Fermentation Centennial,1957

Blessed is he who carries within himself a God, an ideal, and who obeys it: ideal of art, ideal of science, ideal of the gospel virtues. Therein lie the springs of great thoughts and great actions: they all reflect light from the Infinite.

—Louis Pasteur, 1882[2]

1. As quoted in *The Pasteur Fermentation Centennial (1857-1957)*, by Charles Pfizer & Co., Inc., 1958, pp. 5–6.

2. As quoted by William Osler in the introduction to *The Life of Pasteur*

Mankind owes an inestimable debt to Louis Pasteur (1822–1895), who was trained as a chemist, but who asked, and, in part, answered the question: "What is Life, and what separates it from non-life?" He boldly challenged the entire scientific world in biology, and, later, medicine. Through his passionate, moral commitment to easing the burdens of mankind, he revealed the principles governing the unseen world of microbes, realizing the relatively dormant promise of the invention of the microscope two centuries earlier, and laying foundations for the science of public health upon which we depend.

Pasteur was a Platonist, who inspired those around him to delve into the "unseen" reality of the universe without being bound to any axiom. He knew that the universe is lawful and knowable to the creative mind, and that the creative discoveries of which mind is capable, in turn become a force to change man's relationship to nature.

His life's work directly contributed to an increase in the potential population density of the human species, meaning that through improvements in science and technology, mankind can realize a higher standard of living, a longer, more productive life, and an overall increase in the population of the planet as a whole.

Pasteur never limited himself to a particular field of investigation; he considered himself first and foremost a scientist. He strove to understand the mechanism and life cycle of different diseases, not as a formal interest of study, but with a passionate commitment to saving mankind from them.

His ability to cross the boundaries of crystallography, chemistry, and biology in order to solve a problem would be key to his extraordinary discoveries, but it also brought him into conflict with the scientific establishment that had created those divisions of knowledge. The true history of ideas is the repeated revolutionary change in our fundamental understanding of the universe, but it is too often the case that the professional degrees and reputation of the scientists of one generation rest upon knowledge that has become like an axiom, unchanging and unchallengeable. New knowledge that fits within that structure is acceptable, but that which overthrows those axioms is viewed as a threat and is often violently suppressed. Pasteur's unflinching courage in bringing to life new ideas, and his rigor in proving their efficacy, held greater power than the enemies he made during his lifetime.

> Great spirits have always found violent opposition from mediocre minds.
>
> — *Albert Einstein, letter to Morris Raphael Cohen, March 19, 1940.*

Pasteur's Origins

In the early 1800s chemistry was just emerging as a true science, freed from the pseudoscience of alchemy. New elements were being identified (their number jumping from 55 to 81 during Pasteur's lifetime), and great advances were being made in explaining the chemical processes that occurred in living organisms. Key figures from the Ecole Polytechnique, France's premier scientific school, were studying magnetism, the wave nature of light, constructive geometry, and astronomy. François Arago, Jean-Baptiste Biot, Alexander von Humboldt, Joseph Louis Guy-Lussac, Augustin-Jean Fresnel, Etienne-Louis Malus, Eilhard Mitscherlich, André-Marie Ampère, Gaspard Monge, among other leading scientists, were actively collaborating on these topics around the time Pasteur was born.

Louis Pasteur, the son of a tanner, and great-grandson of a slave who had bought his freedom in 1763, was born on December 27, 1822. Growing up, he gained from his father a love of science, and his parents spent considerable effort and money to educate him. His father hoped that Louis would become a celebrated professor of mathematics or science. But Louis found mathematics dry and formal; his love was science, especially chemistry. As a youth, he also loved art and used pastels to paint his parents, and other citizens of the town.[3]

An outstanding student, Louis studied for a time at several colleges, purchasing along the way a chemistry book by Benjamin Franklin, likely a French translation of *Memoirs of Physics*, published in Paris in 1773. In 1839, he arrived in Paris to study at the Ecole Normale Supérieur, where he excelled in chemistry, physics, and teaching. While there, he became a pupil of Jérôme Balard, who had earned a name for himself when, in 1826, at the age of 24, he discovered the element bromine. This had led to Balard's invitation to teach and experiment at the Ecole. A dedicated teacher and researcher,[4] he insisted that his students invent and create their own scientific apparatus. Balard instantly recognized Pasteur's intuitive genius and had him work as an assistant in Chemistry. A short while later, Auguste Laurent, the Professor of Chemistry at the University of Bordeaux and a corresponding member of the Academy of Science, arrived in Paris to pursue his experiments in crystallography. Laurent likewise took a particular interest in Pasteur, whom he asked to work with him.[5]

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by Pasteur's son-in-law René Vallery-Radot, 1907, p. xvi.

3. In November 1863, Pasteur accepted a newly created chair at the School of Fine Arts. He took his students on frequent trips to the Louvre to study the Renaissance masters.

4. Balard slept on a cot in his laboratory so that he would lose no time in his studies.

5. Laurent left the Ecole when he was asked to become the assistant

The Chirality of Crystals and of Life Processes

Developments in crystallography and new techniques in the study of light would enable Pasteur to make his first major contribution to science. In 1846, he decided to make chemistry his life's work: "When I began to pursue specific research, I sought to strengthen my abilities by studying crystals, anticipating that this would provide me with knowledge I could use in the study of chemistry."[6]

Molecules constitute the building blocks of all matter; studying their organization can help reveal their specific function. Since atoms and molecules are too small to be seen, crystals were studied extensively as a way of gaining insight into the spatial arrangement of their atoms and the changes that occur through chemical reactions. For 19th-century scientists, crystallography was a way to reveal the unseen chemical bonding of molecules through the geometrical form of the crystals. In 1819, German chemist Eilhard Mitscherlich developed his theory of *isomorphism* (meaning "having the same shape"), which grouped elements based on the similarity of the compounds and crystals they formed.

Related to this was another tool for seeing the invisible, which became central to Pasteur's discoveries: polarization of light, which limits the passage of light waves through a polarizing medium according to its orientation. The waves in rays of sunlight normally vibrate in all directions, or planes, perpendicular to the motion of the rays. However, in 1808, it had been shown that when light is reflected off water or another flat surface, the waves in the resulting glare all vibrate in one plane; the light is said to be polarized.

A paradox in the phenomenon of polarization led Pasteur to his first major discovery and to subsequent breakthroughs in the science of life. In 1811, François Arago had discovered that some crystals, such as quartz, could rotate the plane of polarized light either to the right or the left, clockwise or counterclockwise with respect to the motion of the light. This was followed in 1815, when Jean-Baptiste Biot—a pioneer in the study and use of polarized light—observed that certain liquids, including turpentine and sugar solutions, could also rotate polarized light. Such substances were called "optically active." A device known as a polarimeter was developed to measure the degree of rotation of light, as it passed through an experimental solution.

lecturer to Jean-Baptiste Dumas at the Sorbonne. At that time, Dumas was the most celebrated chemist in France, a member of the Academy of Sciences and the founder of the Central Institute for training French engineers.

6. Patrice Debré, *Louis Pasteur*, p. 33.

Leatherhead Quartz Crystals

Large quartz crystals. Quartz, an asymmetrical crystal, rotates the plane of polarization of light passing through it.

Life and non-life

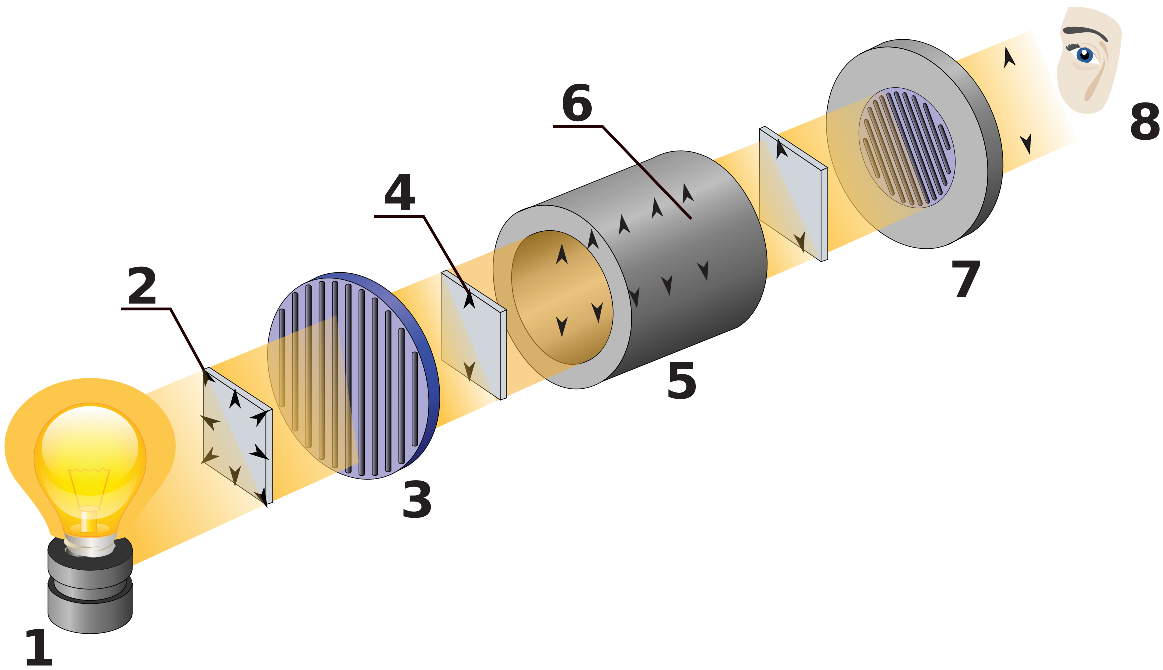
For centuries, crystallized salts called tartrates, formed from tartaric acid in grapes, had been a familiar sight in wine vats, and occasionally on the cork in a bottle of wine. In 1819, a second, very rare form of tartaric acid crystals was found in a few wine vats. These slender, needle-like crystals were called paratartaric or racemic acid. Both kinds of crystals had exactly the same chemical composition and properties, indicating that the arrangement of the atoms should be identical.

In 1832 Jean-Baptiste Biot observed that a solution of tartaric acid rotated the polarization of light to the right, but it was not known why. And twelve years later, Eilhard Mitscherlich submitted a startling report to the French Academy of Sciences on tartaric and paratartaric acid: these acids, although seemingly identical, had different effects on polarized light.

Liquid solutions made from tartaric acid crystals rotated light to the right, as did the crystals themselves, but solutions made from paratartaric acid crystals did nothing! This paradox sparked a tremendous debate in the chemical community. If every physical test known to science indicated that the two compounds were identical in every way, what could cause this optical difference?

Pasteur took up the challenge.

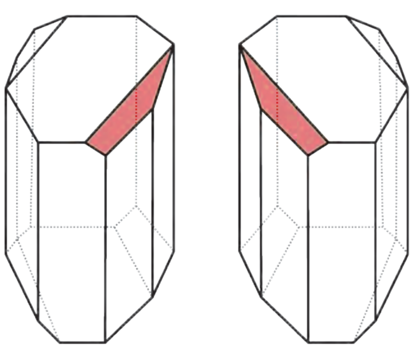
Drawing upon his extensive study of crystals, his insight was to treat these chemical crystals, formed in the course of fermentation of grape juice, as if they were naturally occurring mineral crystals, like quartz. Symmetrical crystals do not rotate polarized light, but dissymmetrical crystals like quartz *do* rotate polarized light. Just like your right and left hands, some crystals can form mirror images of one another. This property of "handedness" is called *chirality* (from the Greek word for *hand*). Pasteur was the first scientist to show that when examined closely, tartrate crystals revealed small secondary



Schematic of the functioning of a polarimeter. Light first passes through polarizing filter **3***, after which all of its oscillating waves are in the same (vertical) plane. As it passes through the test sample* **6***, the plane of polarization is rotated. The angle of rotation is measured by a rotating polarizing filter* **7***, manipulated by the experimenter.*

facets on one side only, making them dissymmetrical. In the same way that quartz crystals rotated polarized light, tartaric acid rotated the plane of polarized light to the right, even when in a solution, because every molecule was right-handed. He had proven that it was the dissymmetry of the molecule itself which caused the rotation. But a question remained: why didn't paratartrate crystals, if they were chemically identical, rotate light?

Pasteur initially thought that the optical inactivity of the paratartrates must be due to a symmetry in the crystalline structure. To test his hypothesis, he allowed a solution of paratartaric acid to crystallize by drying. Pasteur then painstakingly examined each tiny crystal and discovered that these crystals also had dissymmetrical facets. But this time he found both right- and left-handed versions of the crystal! He sorted them into piles of right- and left-handed crystals and then made solutions from each pile. Much to Pasteur's delight, they each rotated polarized light, one to the right and one to the left. The original paratartrate solution hadn't rotated light, because an equal number of left- and right-handed molecules had been formed, canceling out any rotation.



21st Century Science and Technology

Left- and right-handed versions of tartaric acid.

Pasteur was so excited by his discovery that he ran from the lab and exclaimed to the nearest teacher that he had made a wonderful discovery.

The matter was referred to Jean-Baptiste Biot, by then a respected professor, in his 70s, at the Ecole and a member of the French Academy of Science. Biot was initially skeptical of such a profound claim by a 25-year-old assistant chemist. Pasteur reported:

> He [Biot] summoned me to repeat the decisive experiment before his eyes. He gave me the parataratic acid he had carefully studied himself beforehand and which he found to be perfectly neutral toward polarized light... We left the liquid in one of the slow evaporation cabinets he had in his laboratory, and when it had yielded about 30-40 grams of crystals, he asked me to come to the Collège de France in order to gather them and to separate out the right-handed and the left-handed ones according to their crystallographic character under his eyes. He again asked me if I was really saying that the crystals I would place to his right would rotate to the right and the others to the left. This done, he said he would do the rest. He prepared the carefully weighed solutions in the proper amounts, and

Producing Specific Isomers

The production of either left- or right-handed isomers can be done in a number of ways. Pasteur's original insight led him to separate, by hand, the tiny crystals formed by evaporation of the racemic mixture of paratartrates, a technique today called chiral separation. It is usually easier to start with a chiral building block or add one during the synthesis process. If the desired product is not too dissimilar, synthesis can begin with a sugar or amino acid molecule which already has the desired chirality. Or a chiral subunit can be added during the manufacturing process to produce a product with only that chirality. In the case of the cholesterol-lowering medicine Lipitor, this chiral auxiliary is removed at the end of the process, having done its job. A chiral catalyst or enzyme (usually biological in origin) can be used to selectively synthesize a higher proportion of the desired enantiomer. After Pasteur combined a racemic mixture of ammonium tartrate with a *Penicillium glaucum* mold, he found that only the left-handed tartrate remained. This was the first known use of what is now called kinetic resolution of enantiomers. One final technique converts an equal mixture of enantiomers into an equal mixture of diastereomers (non-mirror image molecules which still contain the identical atoms). The non-mirror image molecules then have different chemical properties which allow them to be separated using differences in their boiling points, solubility, etc.

In the case of Thalidomide, a drug used to treat morning sickness, none of these measures would have prevented the birth defects, because Thalidomide can interconvert *in vivo,* switching from one enantiomer to the other. Today, Thalidomide is used to treat leprosy and certain cancers, under strict controls to prevent contact with pregnant women.

Flickr/Luciana Christant

A reminder of the importance of chirality: children with birth defects caused by Thalidomide.

> when the time came to look at them in the polarization apparatus, he again called me to his laboratory. He first placed into the apparatus the most interesting solution, namely the one that was supposed to rotate the light to the left. Without even taking a measurement, Biot realized from the mere sight of the two images in the polarimeter, one ordinary and one extraordinary, that there was indeed a strong rotation to the left. Then, the illustrious old man, visibly moved, took me by the arm and said: "My dear boy, I have loved science so much all my life that this stirs my heart."[7]

Pasteur's discovery was published to great acclaim in 1848, just before his 26th birthday. The tartrates were the first molecules ever isolated in right- and left-handed forms. While the components of living and non-living matter could be chemically identical, Pasteur's further research revealed that virtually every active and naturally occurring biological molecule was exclusively either right- or left-handed. This "asymmetrical force," as Pasteur called it, operates only in living organisms and is the most dramatic boundary condition separating the chemistry of non-living from living matter.

Laboratory synthesis of any dissymmetrical molecule produces equal amounts of each mirror form (*isomer* or *enantiomer*), forming solutions that are therefore optically inactive. *Living* processes, however, uniquely produce only one of the possible forms. Over the next five years, he continued to study isomerism, in the process giving birth to stereochemistry, which studies the three-dimensional shape of molecules.

When both enantiomers exist in living processes, they have different roles. As a modern example, one form of the sugar substitute aspartame is 200 times sweeter than sucrose, while the identical mirror image molecule is bitter.

The infamous drug Thalidomide was prescribed from 1957 to 1961 to relieve nausea suffered by pregnant women, but was banned after severe birth defects were linked to the drug. Later research showed that the right-handed version did relieve nausea, while the left-handed version was responsible for the birth defects.[8]

Today a multi-billion dollar industry is dedicated to increasing the proportion of the desired enantiomer produced through the complex series of chemical reactions required to mass-produce these complex molecules. (See box: Producing Specific Isomers)

The Secret of Fermentation

These discoveries paved the way for Pasteur's entry into research in biology, beginning with an incident in

7. Debré, p. 48.

8. At least one-third of all drugs produced today are chiral, including Ibuprofen, Naproxin, Lipitor, Zocor, Paxil, Zoloft and Nexium. In the case of Ibuprofen, only one enantiomer is biologically active, so it can be sold as a racemic mixture of both forms, but this is not possible with Naproxin, in which the left-handed form is a pain reliever, but the right-handed form is a liver toxin which must be excluded during the manufacturing process.

Fermentation

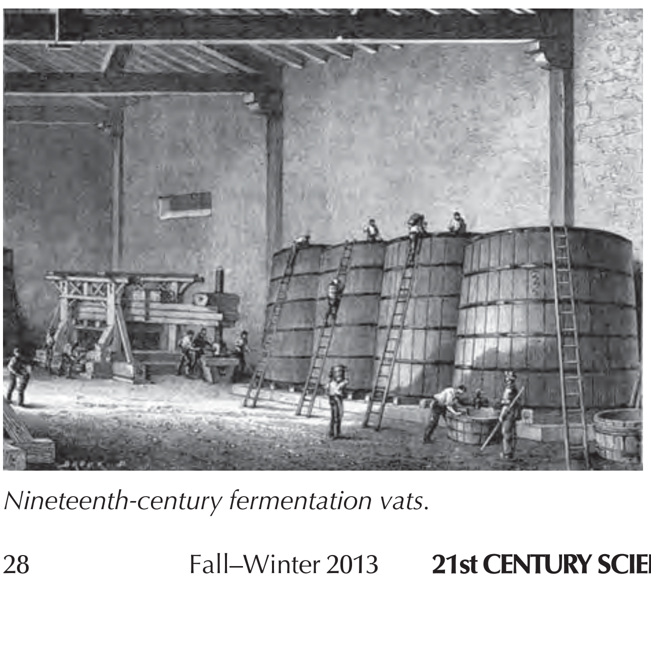
Thousands of years ago, the Greeks and Egyptians made wine and beer; other ancient cultures made rising bread. The knowledge of how all this occurred, however, wasn't discovered until the 19th century. The view taken by the ancients, as well as Pasteur's contemporaries, was that this process was simply a chemical action. Even in Pasteur's time, he was attacked by the prominent German chemist Justus von Leibig, who believed it was simply the action of oxygen, and others who refused to consider this as a life-process.

Great advances were being made in explaining the chemical processes that occurred in living organisms. The great French chemist, Antoine Lavoisier, had shown that the chemical "combustion" in living animals is quantitatively identical to that occurring in a furnace: a carbon-based fuel combines with oxygen, producing energy and carbon dioxide. He also showed that sugar, the raw material for fermentation, could be broken down into alcohol, carbon dioxide, and water by simply dropping droplets of a sugar solution on heated platinum.

1856. At that time, he lived with his wife and two children in Lille, a key industrial center, where he had accepted, at age 31, the chairmanship of the science department and position as Dean of the University.

It was common for working men and industrialists alike to sit in and listen to Pasteur's classes, especially the weekly lecture he gave on chemistry and its application to industry, which were always immediately followed by a visit to a local factory. Pasteur always insisted upon testing, on a large scale, what he had witnessed in the laboratory. This close connection between his laboratory and industry cohered with his immediate sharing of each of his discoveries.

Thus it transpired, that the father of one of Pasteur's students, a leading producer of alcohol from beetroot juice, sought out the professor's help in finding the cause of failed fermentation, where the juice became acidic and fetid, a problem of considerable economic importance to wine- and beer-makers. Pasteur immediately brought his method and microscope to aid in what was to become his first foray into biology and a crucial part of his life's work. To chemists, it seemed absurd, or at least strange, to attempt to study a chemical reaction with a microscope, but Pasteur was always ready to innovate.



Nineteenth-century fermentation vats.

The beet juice was placed in huge wooden vats, where the natural sugar fermented into alcohol. Upon examination of the juice under his microscope, Pasteur observed round globules that grew and multiplied—yeast. Chemical analysis also showed the appearance of optically active amyl alcohol. Based on his work in crystallography and optical activity, these two observations immediately led Pasteur to the hypothesis that the yeast was itself central to the fermentation process.

This was a breakthrough. Although earlier scientists had observed that yeast—a fungus widely distributed outdoors—was present in fermentation, it was thought to be either a product of fermentation or merely a catalyst in a purely *chemical* process. The suggestion that there was a "vitalistic," life force in fermentation was ridiculed by the scientific establishment, and even viewed as a dangerous step backward in science. But Pasteur, not allowing preconceptions to influence his work, recognized that this was no simple chemical reaction; the *living* yeast was converting the sugar into alcohol, carbon dioxide, and water, in order to release energy to fuel its own cellular activity and reproduction.

Pasteur also observed a slimy coating on the surface of the juice in some vats, accompanied by a sour smell. Upon microscopic examination, he saw not the round yeast he expected, but instead, huge numbers of tiny, black rods. Pasteur concluded that this, too, was a life process and that the rod-shaped organisms were a new class of yeast, which, he found, produced lactic acid instead of alcohol, ruining the entire vat of juice. Through months of study, he was able to show that some yeast was responsible for the fermentation of sugar into alcohol in wine and beer, while other yeasts or bacteria were responsible for converting alcohol to acetic acid in vinegar, and also lactose to lactic acid in yogurt. It was these unintended microbes that caused ferments to sour, not simple chemical reactions.[9] While he now understood

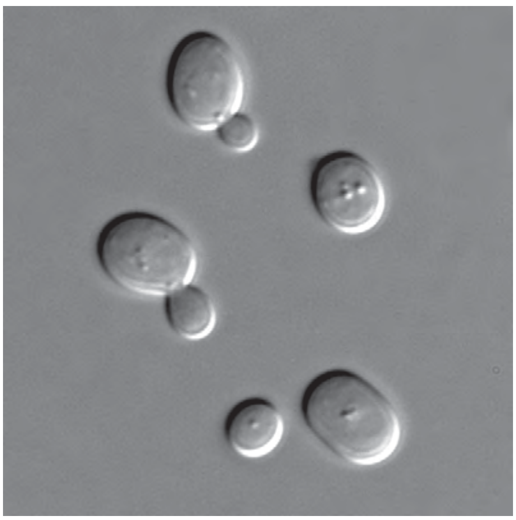
9. Pasteur referred to fermentation as "life without oxygen." In the development of life on Earth, this was the mode of respiration and energy production in organisms prior to the emergence of photosynthe-

why the presence of unwanted microorganisms would ruin the fermentation, his solution took a few more years to develop.

In 1857, Pasteur published a paper on lactic fermentation which laid out all the essential concepts of his discovery, a paper which has been referred to as the birth certificate of microbiology, due to his key insight that fermentation is *caused* by living organisms. His paper concludes:

> My present and most fixed opinion regarding the nature of alcoholic fermentation is this: The chemical act of fermentation is essentially a phenomenon correlative with a vital act, beginning and ending with the latter. I believe that there is never any alcoholic fermentation without there being simultaneously the organization, development, and multiplication of the globules, or the pursued, continued life of globules which are already formed.[10]

In order to kill most of the unintended bacteria present, without damaging taste or nutritional value, in 1862 Pasteur conducted his first experiments to test the effect of briefly heating wine and beer. This dramatically increased the "shelf life" of these products. By 1865, he had developed what we now know as the process of *pasteurization*. The 1876 publication of Pasteur's "Studies on Fermentation: The Diseases of Beer, Their Causes,



Budding yeast cells, the cause *of fermentation.*

sis and its release of oxygen into the atmosphere, and is also the mode of energy production that occurs during brief strenuous muscular exertion. Human bodies can produce energy without oxygen, forming lactic acid, the cause of both sore muscles, and sour milk.

10. Pasteur, "Mémoire sur la fermentation alcoolique," *Annales de Chimie et de Physique* (1860), **58**:3, 359–360, as translated in Joseph S. Fruton, *Proteins, Enzymes, Genes: The Interplay of Chemistry and Biology* (1999), p. 137.

A van Leeuwenhoek microscope, circa 1668

and the Means of Preventing Them" was a huge leap forward in the scientific understanding of beer-making, followed in subsequent years by the pasteurization of milk and many other products. The book was translated and published in English in 1879, and was studied by brewers around the world. In Copenhagen are found Pasteur Street and a statue of the great scientist, thanks to whom the Carlsberg Brewing Co. successfully sent a shipment of beer all the way to India.

The process of pasteurization is probably the only universally known discovery by Pasteur in the world today, a sorry "sign of the times" in which we live.

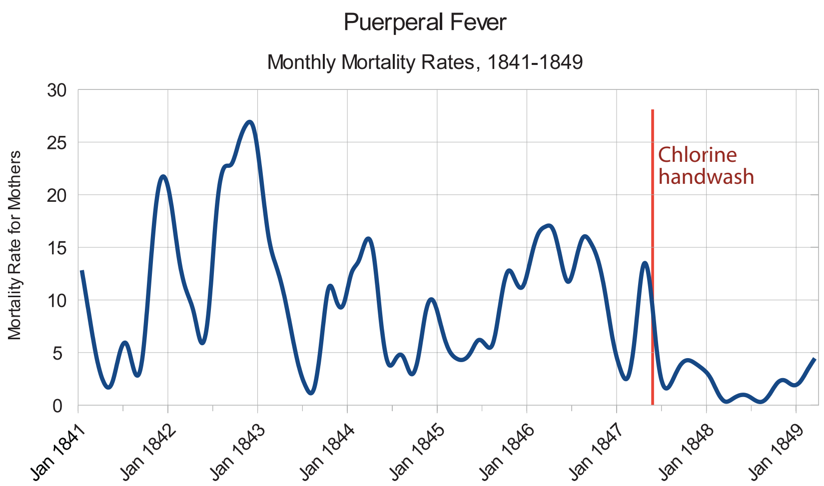
Germ Theory

Men have speculated since ancient times that living agents could enter the body and cause disease, but until the invention of the microscope in the 1660s, that speculation could not be verified. However, as we will see, it was not the power of the microscope to enhance vision, but the power of insight, the rigor of method, and the courage to challenge accepted precepts, that led to the breakthroughs in knowledge upon which our health today depends. Prior to the mid-nineteenth century, disease was generally viewed as a miasma, akin to a poisonous gas, which could infect many people, but was not transmitted from person to person—this, although Antonie van Leeuwenhoek of Holland had opened up a new world of perception with his first microscope in 1668. He was the first to see and describe bacteria, yeast globules (which he believed to be nonliving, starchy structures), drops of water teeming with new forms of life, and the circulation of blood corpuscles in capillaries. But who could know what it all implied?

The case of the Italian Agostino Bassi is illustrative. He is often credited with having stated the germ theory of disease for the first time, based on his observations of the lethal and epidemic muscardine disease of silkworms. In 1835 he blamed the deaths specifically on a contagious, living agent, visible to the naked eye as powdery spore masses (later named *Beauveria bassiana* in his honor).

But despite this and other early insights, a scientific understanding of the nature of microbes, how they invaded the body and actually caused disease, remained elusive.

Under these conditions, battlefield and even hospital medicine were atrocious. The majority of wounded soldiers died of infection, not from actual combat. Doctors rarely washed their hands or surgical instruments, and bandages were taken off the dead and immediately reused on wounded soldiers.



Mortality rates from Puerperal Fever among women giving birth at the Vienna General Hospital. Note the plunge in deaths after Semmelweis instituted simple hand washing with chlorinated water in 1847.

Women giving birth faced similar odds. At the Paris Hospital, the death rate among women in labor was 20–25%. In 1847, Ignaz Semmelweis, a Hungarian obstetrician working at Vienna's Allgemeines Krankenhaus (hospital), began seeking a reason for the dramatically high incidence of death from puerperal fever (also called childbed fever, most commonly caused by *Streptococcus* or *Staphylococcus* bacteria) among women who delivered at the hospital with the help of the doctors and medical students. In contrast, births at home, attended by midwives, were relatively safe. Investigating further, Semmelweis observed that the delivery physicians often came directly from autopsies performed on mothers who had died the previous day. Asserting that puerperal fever was a contagious disease and that "cadaverous particles" were implicated in its development, Semmelweis made doctors wash their hands with chlorinated lime water before examining pregnant women. Mortality from childbirth fell to less than 2% at his hospital. Nevertheless, he and his theories were ignored or viciously attacked by most of the Viennese medical establishment. A typical response was, "Doctors are gentlemen, and gentlemen's hands are clean."[11]

11. A 1938 film, based on Semmelweis' work, *That Mothers Might Live*, was awarded the Oscar for Best Short Film.

Spontaneous Generation

In 1858, at the same time Pasteur was doing his ground-breaking work on fermentation, he became embroiled in a bitter fight over the nature and origin of life itself. Adherents of spontaneous generation, led in France by Félix-Archimède Pouchet, the director of the Natural History Museum of Rouen, believed that life could arise spontaneously from non-life. It was not a new debate. Aristotle had asserted that life could arise spontaneously out of dirt and dust: "every dry body which becomes moist and every humid body which dries up breeds life."[12] In the early 1600s, Flemish physician and alchemist Jan van Helmont wrote: "the emanations rising from the bottom of marshes bring forth frogs, snails, leeches, herbs, and a good many other things." He also maintained that mice could arise from corn and a dirty shirt left in a vessel for three weeks.[13]

Pasteur knew he was entering a hostile arena. His colleague and good friend Jean-Baptiste Biot begged him not to enter the fray. It is far more difficult, he argued, to prove something *cannot* exist than to prove something *does* exist. But Pasteur knew, from his work on crystallography and fermentation, that this fundamental issue would generate valuable insights far beyond questions of frogs and mice. His entrance into the scientific battle increased its prominence, and all of France began to follow the experiments made by each side. In April, 1860, the *Moniteur Scientifique* asked: "What will be the outcome of this battle of the giants?"[14]

Pasteur's grandson, Pasteur Vallery-Radot, later wrote of the contest:

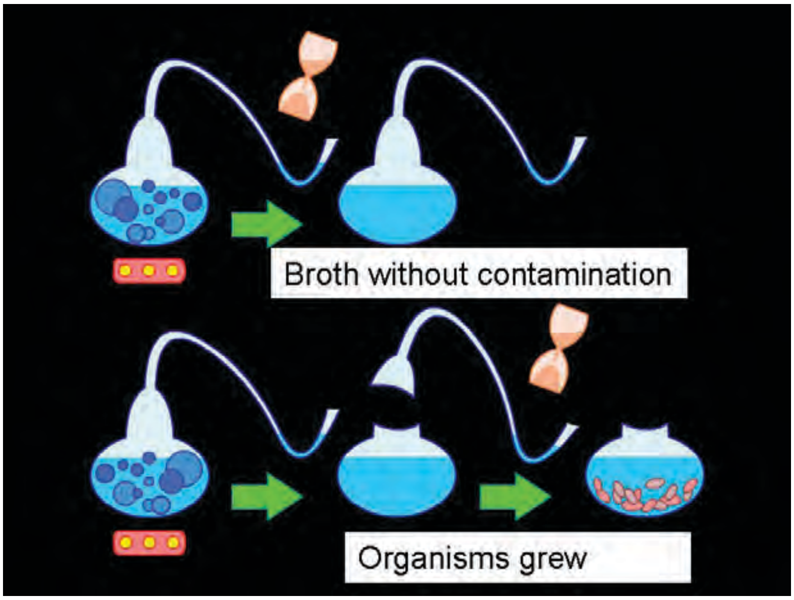
> While Pasteur had no preconceived idea and simply expected from the experiment the answer to a given problem, Pouchet wanted the experiments to confirm

12. As quoted in Pasteur Vallery-Radot, p. 58.

13. Pasteur Vallery-Radot, pp. 58–59.

14. Debré, p. 163.

what he already believed "by meditation." Thus Pouchet violated the basic rule of a scientific experiment, which is that the gravest error lies in the desire to confirm what one believes; indeed one must always experiment without prejudging the outcome. As Bossuet said: "It is the worst aberration of the mind to believe things because one wishes them to be so." . . . What polemics and controversies to establish definitely the doctrine of the non-spontaneity of germs! Pasteur devised the most ingenious experiments, revealing the remarkable fertility of his imagination, his prowess as an experimenter, and at the same time displaying his forceful argumentation. . . challenged the views of his peers, overwhelmed his opponents with experiments. . . He smashed their objections one after another.[15]



Representation of how Pasteur's swan-necked flask experiments disproved spontaneous generation.

Pouchet believed that germs were very rare and could not account for all the organisms seen. He argued that if germs were everywhere, the air would be so thick that it would have the density of iron.

Pasteur wrote to Pouchet that the results he had attained were:

. . . not founded on facts of a faultless exactitude. I think you are wrong, not in believing in spontaneous generation (for it is difficult in such a case not to have a preconceived idea), but in affirming its existence. In experimental science it is always a mistake not to doubt when facts do not compel affirmation. . . In my opinion, the question is wholly untouched by decisive proofs. What is there in air which provokes organization? Are they germs? Is it a solid? Is it a gas? Is it a fluid? Is it a principle such as ozone? All this is unknown and invites experiment.[16]

Pasteur, as always, took a rigorous experimental approach, using the skills learned from Prof. Balard in making his own instruments, with an ingenious invention to prove his germ theory. He created a new kind of flask. It looked like a bulb with a doubly curved, thin opening resembling the neck of a swan. In it he put water, sugar, and yeast. He heated the flask until it boiled and then simmered the mixture in order to kill any organisms present.[17] After allowing the flask to cool, he inserted a small wad of cotton into the end of the neck. The long, narrow neck allowed air to enter, while preventing any germs or dust from entering the flask. The liquid inside the flask remained clear and free of organisms for months or years. When he broke the neck, or tilted the flask allowing some of the solution to run down the neck and back into the flask, microbes were allowed to enter the flask, multiply and make the solution cloudy.

Pasteur concluded that germs in the air had to be introduced to the flask to produce life. To further refine his hypothesis, he took his experiments 6500 feet in elevation up Mont Blanc, where the air was purer than that in the city. When the sealed, sterile flasks were opened high on the mountain, fewer of the flasks became cloudy. This confirmed for Pasteur that air in some areas was nearly germ-free and that germs were the sole source of life in the experiment. He repeatedly demonstrated that a fermentable liquid, if sterilized and exposed to only the purest air, would lie dormant.

Pouchet made new challenges and experiments, similar to Pasteur's, but, without the latter's rigorous controls, always resulting in solutions teeming with germs. Life could start in any place, he asserted, and growth is found in every case, regardless of the quality of the air used.

When the Academy of Science was called to test both Pasteur's and Pouchet's experiments, Pouchet gave up in the middle of his experimentation, while Pasteur had produced over 60 successful flasks. Still, the debate continued, and on April 7, 1864, Pasteur gave a lecture at the Sorbonne in Paris. Referring to his swan-neck flask experiments, Pasteur said, "Never will the doctrine of spontaneous generation recover from the mortal blow

15. Pasteur Vallery-Radot, p. 62.

16. René Vallery-Radot, p. 94.

17. The Italian scientist Lazzaro Spallanzani had shown in the 18th century that boiling killed these tiny creatures.

struck by this simple experiment." He went on to say:

> As I show you this liquid, I too could tell you, "I took my drop of water from the immensity of creation, and I took it filled with that fecund jelly . . . full of the elements needed for the development of lower creatures. And then I waited, and I observed, and I asked questions of it, and I asked it to repeat the original act of creation for me; what a sight that would be! But it is silent! It has been silent for several years, ever since I began these experiments. Yes! And it is because I have kept away from it, and am keeping away from it to this moment, the only thing that it has not been given to man to produce, I have kept away from it the germs that are floating in the air, I have kept away from it life, for life is the germ, and the germ is life."[18]

Pasteur received a standing ovation from the large majority of attendees. His experiments regarding germ theory were not the first, but they were the most rigorous. The sterilization techniques Pasteur developed led to the autoclaving of instruments (using steam at high pressure to sterilize), invented by one of Pasteur's students, Charles Chamberland, which drastically reduced infection caused by surgical instruments.

Despite these and other results, the theory of Spontaneous Generation would still have supporters for some decades. In 1882 (20 years later!), Louis again attacked the remaining supporters of Spontaneous Generation and the religious leaders who supported their claim: "This has nothing to do with religion, or with philosophy, or with systems of any kind. Assertions and *a priori* views do not count; we are dealing with facts." Looking back at the end of his life, Pasteur said:

> Spontaneous Generation is something I have been looking for without finding it for twenty years. No, I do not consider it impossible. But on what grounds do you think you can say that it was the origin of life? … Who tells you that the steady advancement of science will not oblige scientists living a hundred years, a thousand, ten thousand years from now... to maintain that life has existed for all eternity, but not matter? You move from matter to life because your current intelligence, so limited in comparison with the intelligence of future naturalists, tells you that it cannot think otherwise. Who can assure me that in ten thousand years it will not be considered impossible to think that life does not change into matter?[19]

18. Debré, p. 169.

19. Debré, pp. 175–176.

Flickr/guojerry

A silkworm and cocoon, spun from a single strand of silk, one kilometer long.

Rescuing the Silk Industry

Pasteur's success in revealing the cause of diseases of wine, milk, vinegar, and beer, had led him to conclude that such "microbes" were also responsible for the diseases afflicting animals and man—a revolutionary idea. As in the beet root case, he found himself called upon to solve an important agro-industrial problem.

The French had been involved in sericulture—the rearing of silkworms—for several centuries. By the middle of the nineteenth century, annual production had reached 26 million kilograms of silk. But disaster struck. An epidemic disease ravaged the silkworms, collapsing French production to just four million kilograms by 1865. At first, silkworm rearers had resorted to buying eggs abroad, but the disease had spread globally, and only the island nation of Japan seemed to have avoided the scourge. Even healthy imported broods succumbed to the disease within a few years of their arrival in France. The government received a petition signed by thousands of French mayors, councilmen and landowners, demanding that the government send an entomologist or veterinarian to find a cure. Pasteur's former teacher, Jean-Baptiste Dumas, a member of the French Senate as well as a scientist, believed that Pasteur's fermentation experience uniquely qualified him. He begged Pasteur to take the job, despite the fact that he was a chemist and had never even seen a silkworm! To Pasteur's protests, Dumas replied: "All the better, for you will have no preconceived ideas and will be guided by the results of your own work."[20] Pasteur was to spend much of the next six years working on this problem.

The disease killing the silkworms was called *pébrine* (after the French word for pepper), because black spots

20. Fishbein, p. 30.

appeared on the worms. Also, their tissue contained minute, oval, shiny corpuscles 2–3 micrometers in length. If these corpuscles were found in a sampling of eggs, the entire brood was likely to fail. Outbreaks could occur at any stage in the silkworms' development, often among apparently healthy worms. One batch of eggs could produce healthy worms, while a second batch of eggs, kept under identical conditions and fed the same mulberry leaves, could produce solely diseased worms.[21]

Pasteur's visits to many silkworm rearers revealed a vast number of theories with an equal number of "experts" to explain them. "Cures" included applying chlorine gas, sulphur, coal dust, wine, rum, acids, tar vapors, numerous "secret" ingredients, and even electrical currents. Yet the destruction continued. And even in the major sericulture center of Alais, no one had either seen, or had even expressed the desire to see, under a microscope, any of the corpuscles whose existence had been known since 1849.

"I decided," wrote Pasteur, "to adopt a line of approach very different from that of my predecessors. I would concentrate my attention on one given point, the most significant I could find, and not give up my study of it until I had established a certain number of principles which would allow me to advance with safety into the labyrinth of preconceived ideas. . . I will, for the moment, direct my attention exclusively to an examination of the questions raised by the presence of the corpuscles."[22]

Joseph Lister, the English physician who championed antiseptic medicine.

Thus in 1865, Pasteur began a series of controlled experiments to develop a clear chain of causation. He microscopically examined the tissue of eggs, worms, pupae, and moths at all stages of life and correlated these findings with the future health of the individual worms and the quality of the silk produced from their cocoons. This was no easy task, because nearly all of the moths and pupae were infected. In February 1866, he brought two former students to Alais, whom he trusted to be his assistants, Désiré Gernez and Eugène Maillot, later joined by Emile Duclaux. Pasteur was in the process of creating a science youth movement from among the young doctors and scientists not tied to the old assumptions and doctrines held as sacrosanct by the high priests of French medicine.

Pasteur and his assistants rose at 4:30 every morning. The first order of business besides checking on the silkworms, was to painstakingly sanitize the work area completely. Everything and every surface, including the walls, had to be hygienic to rule out contamination by dirt and microbial dust.

Pasteur was able to prove that the disease was contagious and transmitted by a parasite, and then worked to show how the disease was transmitted. He developed a method of testing about 100 pupae and 100 moths that allowed him to predict the health of 25–30,000 eggs, and by 1867, his methods of testing and sanitation were applied with excellent results, showing that the environment played a huge role in the spread of the disease.

But, other silkworms died that were free of the corpuscles. This paradoxical situation gradually led him to conclude that there was a second disease called *flacherie*, in which the worms became soft and flabby. Pasteur studied this disease from 1867–69 and found organisms in the worms' intestines which resembled the fermentation agents he had already studied. The bacteria could be transmitted via the mulberry leaves fed to the worms, especially if the leaves were cut, wet, or had excrement from the worms.

Pasteur biographer Patrice Debré describes the disease and its cure: "It should be pointed out that the description of the multiple causes that facilitate the proliferation of the microbes responsible for flacherie, whether they be bacteria or viruses, was less important than the fact that Pasteur had established that this was indeed an infection and that he had attempted to prevent it. On the basis of his finding, he proposed a series of hygienic measures, including better ventilation for the nurseries, scrubbing the floors, careful management of the silkworms' food, the picking and conservation of the mulberry leaves, and prevention of heat and humidity from pervading the atmosphere of the breeding chambers."[23]

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21. The silkworm goes through two metamorphoses within the cocoon, forming a chrysalis—a kind of mummy—and later a pupa, which finally emerges as a moth to continue the cycle by laying a new generation of eggs.

22. Nicolle, p. 114.

23. Debré, p. 205. Debré writes: "Emil Roux later wrote of Pasteur's book on the silkworm that it was a veritable guide for anyone who undertook to study contagious diseases. Pasteur was aware of this and pointed it out to the physicians. He never failed to say to those who came to work in his laboratory, chosen by him to collaborate in his study of infection in animals: 'Read the Etudes sur la maladie des vers

The potential value of this anti-septic approach was quickly recognized by the English physician Joseph Lister, who became a strong supporter of Pasteur and began corresponding with him in 1874. Practicing in Scotland, he began a campaign for a germ-free surgical environment. Lister ended the practice of re-using bandages, demanding absolutely clean linen, and successfully used carbolic acid to sterilize wounds and the entire operating theater. Like Semmelweis earlier, Lister became a target of attack by the medical establishment. Yet, his success rate was more than double that typical beforehand. A turning point in the acceptance of Lister's methods came in 1876, when he was invited to speak at the International Medical Congress held in conjunction with the U.S. Centennial Celebration in Philadelphia. Among those in the audience was Robert Wood Johnson, who was already greatly influenced by Lister's ideas and went on to manufacture and market the first commercial sterile surgical bandages. He and his two brothers founded Johnson & Johnson in 1886. An increasing number of physicians began to adopt Lister's aseptic approach to surgery and wound treatment, dramatically reducing mortality rates.

For the first time, the origin of a disease in a living organism had been traced to the action of a microbe. Pasteur's new hypothesis saved the French silkworm industry and the livelihoods of the farmers who were nearly wiped out by the disease. He considered the potential of using the killing power of certain microbes to eliminate harmful insects or parasites that ravaged crops. Equally important, Pasteur's work on silkworms would help him tackle other biological problems, saving mankind from a host of diseases. His experiments led him to believe that addressing filthy conditions and over-crowding were an essential aspect of treating human disease. Pasteur fought to organize the French government to provide adequate supplies of fresh water as well as a sewage system, to prevent the spread of deadly diseases like cholera. While others had discussed the presence of microbes and their possible role in disease, Pasteur's work was the beginning of a rigorous and powerful germ theory because of his commitment to conquer these diseases. Through meticulous experimentation he developed an arsenal of ideas which fundamentally shifted the battle.

The history of science is incomprehensible without recognition of the role of morality such as Pasteur's. In contrast, the British parson and East India Company employee Thomas Malthus (1766–1834) explicitly rejected the idea that human society was perfectible and saw famine and disease as "natural" checks on the growth of population. He attacked doctors who sought to cure diseases, and instead, encouraged over-crowded and filthy conditions in the slums of London, in order to increase the death rate among the "undesireables." Thus are the scientific and economic policies of nations intimately related to their view of the nature of Man.

In Part II (to appear in the next issue), we will study Pasteur's extraordinary years of discovery, focusing on his triumphs over anthrax and rabies. A short companion article, will look at the impact of Pasteur's work on later scientists as well as investigations of chirality being undertaken today.

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Yassine Mrabet

à soie, for I think that it will be a good preparation for the work we are about to undertake.'"

Expanding NAWAPA XXI: Weather Modification to Stop Starvation

by Benjamin Deniston

Lyndon LaRouche has recently emphasized the need to accelerate the construction of the North American Water and Power Alliance (NAWAPA) for the very survival of the United States.[1] Because of the Anglo-Dutch directed environmentalist coup against our nation-building, pro-growth traditions typified by the presidencies of Franklin Roosevelt and John F. Kennedy, the United States is suffering from a long-building water crisis.[2] Options for new water supplies have either been blocked or ignored, and supplies of ground water (the only source for entire sections of the West) have been overused and abused.

This now poses an existential threat to food production and supplies, exacerbated by the genocidal continuation of the biofuels insanity, converting precious crop land to fuel while millions starve.[3]

Given the level of the crisis, all available scientific capabilities should be applied to the defense of the water, food, and livelihood of the people of North America, *including systems to influence and control the weather*. Weather modification systems can bring rain to regions of the West where it is so desperately needed, providing near- to medium-term emergency relief, and can be designed to operate in conjunction with the nuclear-powered NAWAPA XXI system as it is being constructed and implemented.

This technology is not the more familiar cloud-seeding; it relies on ground-based electrical systems which ionize local regions of the atmosphere, allowing for the controlled modulation of its ionization level, which in turn affects water vapor condensation, cloud formation, latent heat release, the local conductivity of the global electric circuit, and related processes affecting the weather.

This is not a theoretical project. Already, ionization systems have been used to increase rainfall in regions of Russia, Mexico, Australia, and the United Arab Emirates (and additional non-public operations in other nations)—providing multiple, independent demonstrations that have shown significant levels of success.

For the United States, similar systems can be integrated with the NAWAPA XXI ocean-continental water management system, enhancing the principle of NAWAPA itself:

> To provide greater control over the water cycle of the North American continent and its surrounding oceans (bringing the water to the needed locations while ensuring excess water does not burden the regions where it is not needed), and, above all, increasing the productivity of that water, by ensuring its participation in a greater density of photosynthetic, biological, and human economic activity, raising the value and the productivity of the North American continent.

It is possible that ionization-based systems could be brought in to accelerate that process, by influencing the existing air moisture and rainfall patterns. While this could even provide some short-term relief from the immediate drought conditions, its ultimate success absolutely depends upon the central role of NAWAPA XXI.

With the existential and deadly threat of water and food shortages plaguing this nation, it would be criminal to refuse to seriously investigate all scientific options available to mankind for alleviating the crisis.

The NAWAPA Principle

NAWAPA is a long overdue next step in mankind's improvement of the biospheric productivity and human economy of the North American continent. Going back thousands of years, the growth of the human species has been intimately tied to the conscious control and improvement of water supplies. The governing principle has always been, and must continue to be man *increasing the productivity of the water cycle,* as expressed in the increased use and re-use of water in biological or industrial processes.

The idea that we simply "use up" fresh water is beyond silly.

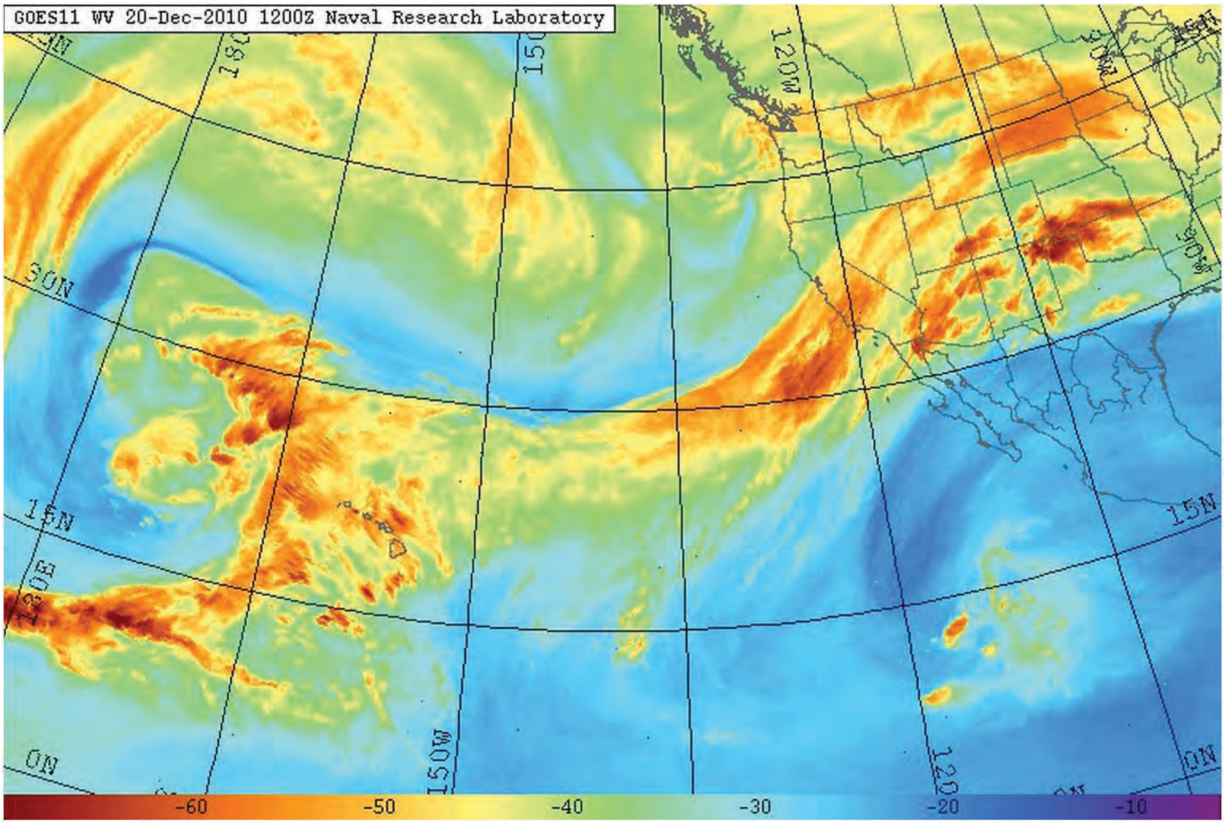


Figure 1

US Naval Research Laboratory, Monterey, Calif.

Water vapor over the eastern Pacific Ocean imaged by the GOES 11 satellite in December 2010. Notice the large atmospheric river aimed across California. This particularly intense storm system produced as much as 26 inches of rainfall in California and up to 17 feet of snowfall in the Sierra Nevada from December 17–22, 2010.

For example, the Sun does an impressive amount of work to evaporate huge amounts of water. Of the total amount of solar radiation reaching the Earth (173 million gigawatts), 25% of the energy flux goes into the continuous evaporation of water! This means a very large amount of water (and potential energy) exists in the form of water vapor, floating over our heads at all times.

While the quantity of water in the air is itself remarkable, so is the structure. Since the 1990s, scientists have known about "atmospheric rivers," narrow corridors or filaments of concentrated water vapor flowing high above the Earth's surface. They have been measured to occupy only 10% of the area of the mid-latitudes, but carry 90% of the moisture moving from the tropics to the poles—expressing concentrated structures, as opposed to a homogenous distribution.

Some atmospheric rivers bear a greater flow than the largest (land) river on Earth, the Amazon.[4]

When this water falls as rain over the land, it allows the growth of plants, the base of life's land-based food-web, and the ultimate source of the vast majority of food for mankind (the only exception being seafood). The ultimate source of the rivers, lakes, and ground water we use for our needs, is the process of evaporation and rainfall.

So, there is no "limited supply" of water, and water is not a resource that is getting "used up." Mankind simply has to manage and improve the already existing larger cycles, because the unaided biosphere by itself is not always very effective in its hydrological distribution.

For example, as pertains to NAWAPA, the natural wind, ocean, and geographic systems of North America result in a terrible discrepancy in the distribution of fresh water across the western half of the continent. As seen in the image, a narrow strip of the coastal region ranging from Alaska, through Yukon, down to Washington receives a density of rainfall much greater than anywhere in the West or Southwest, and the related northern water basins of Alaska, British Columbia, and Yukon provide 40 times more freshwater runoff than the entire Southwest and northern Mexico. Unfortunately, much of this northern water quickly runs off into the ocean with little or no productive use by the biosphere.

What a terrible waste of the Sun's work!

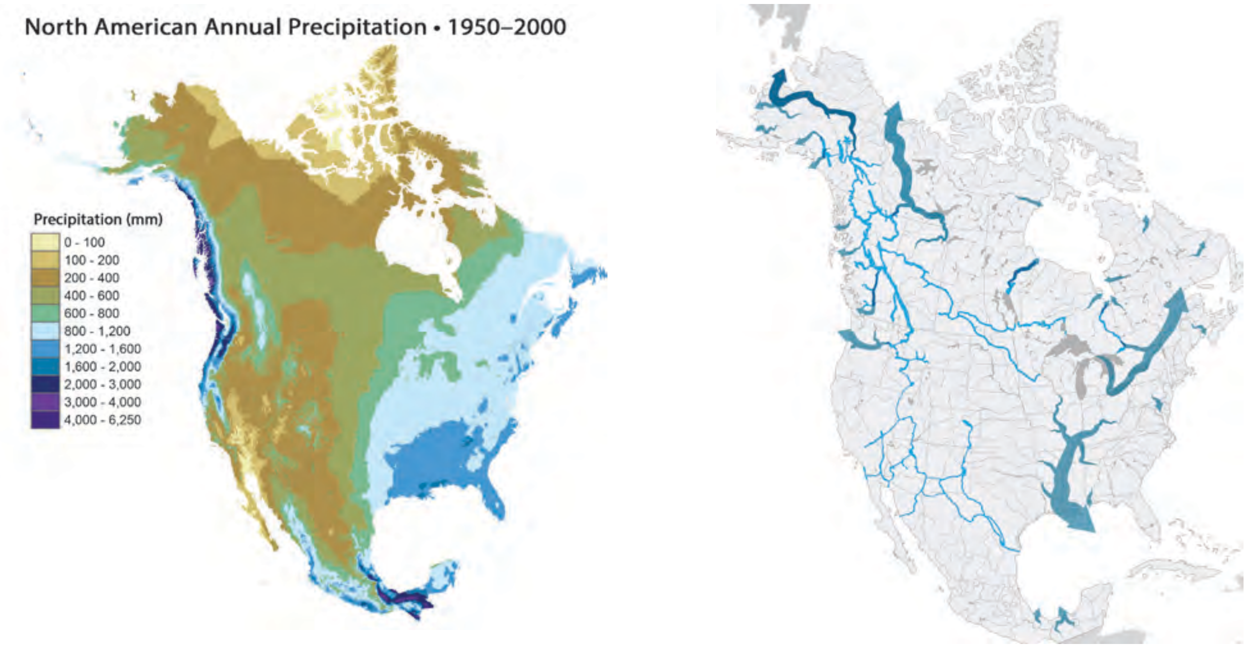


Figure 2

Left: INEGI, NR-Can, USGS, North American Environmental Atlas of the Commission for Environmental Cooperation, Right: LaRouchePAC

Left: Annual precipitation for North America.
Right: The NAWAPA system, along with arrows scaled to the current freshwater runoff rates for all the major river systems of North America (notice the lack of runoff in the West and Southwest).

NAWAPA could dramatically increase the biospheric productivity per square kilometer of the western half of North America, by redistributing 20% of the otherwise wasted freshwater runoff from coastal Alaska and British Columbia into the Southwest with a relative handful of dams, a series of natural canals and rivers, and the construction of tunnels, pumps, and related systems. Much of this water would eventually return back to the ocean, but, thanks to NAWAPA, it would first participate in photosynthetic, biological, and economic processes many times throughout the Southwest, greatly increasing the productivity of the water cycle.

Since NAWAPA was not constructed when it was proposed in the 1960s, the interconnected water and food crises have become existential, and LaRouche, after calling for a relaunching and upgrading of the NAWAPA project in the fall of 2010, has continued to emphasize that the construction and implementation must be rapidly accelerated—*with nuclear power being a key driver to increase the capabilities and rate of development of the NAWAPA system.*

By the original Parsons design, NAWAPA was expected to take 20-30 years to construct. LaRouche PAC's assessment, in consultation with a committee of experts, is that that can be accelerated to 15–20 years (or perhaps even faster), depending upon the level of investment.

Whereas the original design called for releasing a significant amount of water from the system down into the Pacific ocean to generate hydroelectricity to power the pump lift components of NAWAPA, using nuclear power instead would mean that precious water wouldn't have to be released for power generation, and the water available for distribution in the Southwest could potentially double.

Nuclear power can also provide large amounts of desalinated ocean water at key coastal regions, either feeding directly into NAWAPA or providing another subcomponent of the continental system, and is the highest level of energy flux density immediately available. It must be utilized to accelerate and strengthen the NAWAPA system.

Within this commitment for the construction of NAWAPA—centered upon creating this more intense and productive utilization of the water cycle of the continent as a whole—weather modification systems can be utilized to further expand the deliberate management and control of the moisture cycles.

Weather Modification via Ionization

The basis for the weather modification systems discussed here lies in what could broadly be associated with the electrical, ionization, latent heat, and related properties of atmospheric and weather systems, and the effects additional ionization and electrical inputs can have on these systems.

For example, as early as 1989, one of Russia's leading scientists in the field of solar-terrestrial physics, M. I. Pudovkin, put forward the hypothesis that galactic cosmic radiation was affecting the Earth's climate and weather.[5] Over the subsequent years, Pudovkin and his team became a leading group among a growing movement studying this galactic-solar-Earth interaction.[6]

In the West, this has been most popularized starting in the late 1990s, when the Danish physicist Professor Henrik Svensmark began to champion a new science of "cosmoclimatology." Svensmark and his associates showed very close correlations between changes in global cloud cover and variations in galactic cosmic radiation, and proposed that the ionizing effects of cosmic radiation were playing a role in stimulating cloud formation, and thus affecting the climate.[7]

He posited that the ions created by galactic cosmic radiation become nuclei around which water vapor can condense, and these growing clusters of condensation can build up to become clouds.

An important emphasis should also be placed on the effects of the condensation process itself. When water changes state from gas to liquid form it releases energy—referred to as latent heat release. Recognizing that fully *one-fourth* of incident solar energy is, in a sense, stored in the process of the evaporation of water, means there is a huge amount of potential energy throughout the atmosphere at all times, waiting to be released as heat when the water is induced to return to a liquid state.

Recognizing the role of ionization in stimulating condensation, and thus the release of latent heat, means that changes in ionization levels, in addition to having the potential to stimulate cloud formation and rainfall, can also affect large stores of atmospheric energy. There are indications that this can even influence hurricanes and cyclones (see box: Cosmic Rays and Katrina).

Even though the exact details involved in the process leading from ionization to cloud formation have been the subject of academic debate for years, the reality of the food and water crises facing the American people demands the discussion leave the domain of academia, and enter active investigation and experimentation.[8]

Can we effectively act upon these processes for purposes of weather modification? Specifically, can we control rainfall patterns?

For decades now, one technique has been to construct towers supporting networks of thin electrical wires, through which specifically tuned currents produce an ionization of the immediately surrounding air. The ionized air then propagates into the surrounding atmosphere

Cosmic Rays and Katrina

A 2008 study showed a relationship between galactic cosmic rays, solar activity, and the infamous hurricane Katrina, which devastated New Orleans in 2005.[1]

As described in the study, one key component in the intensity of cyclones and hurricanes is the temperature difference between the relatively warm ocean, compared with the colder upper atmosphere. A greater temperature difference leads to a more intense convection process, where the warmer ocean air rises up to meet the colder air high in the atmosphere above.

In the case of Katrina, while the storm was out over the Atlantic Ocean the Earth's magnetic field entered a period of intense fluctuation, known as a "geomagnetic storm,"[2] which can, in turn, reduce the galactic cosmic rays entering the Earth's atmosphere, because the Earth's magnetic field generally acts to deflect charged particles such as galactic cosmic rays. This is a well-known phenomenon, called a Forebush decrease.

As discussed above, the constant inflow of cosmic rays causes an ionization of the Earth's atmosphere, inducing condensation of water vapor, *and the release of latent heat*. Because this release plays an active role in warming the already cold upper atmosphere, if the cosmic ray flux is reduced, so then is the ionization, condensation, and latent heat release—leading to a further cooling of the upper atmosphere.

As Katrina approached the Gulf of Mexico, the reduction of the cosmic ray flux caused by the geomagnetic storm of August 24–25 led to a 9°C drop in the temperature of the upper atmosphere, and a consequent increase in the intensity of the hurricane, since this increased the temperature difference between the warmer ocean and the now even colder upper atmosphere, resulting in increased convention and intensity.

In the context of discussing active weather modification, it is worth considering the possibility that perhaps such stores of potential energy (latent heat) could be actively modulated by mankind to defend our population against storm systems. If less ionization / condensation can lead to an intensification, then perhaps increasing the ionization / condensation could be used to weaken threatening storms as well?

1. See, "Role of Variations in Galactic Cosmic Rays in Tropical Cyclogenesis: Evidence of Hurricane Katrina," in *Doklady Earth Sciences*, 2008, Volume 422, No. 7, pp.1124-1128; by Bondur, V. G.; Pulinets, S. A.; Kim, G. A.

2. Geomagnetic storms are generated by strong outbursts of solar activity which bombard and rattle the Earth's magnetic field, causing fluctuations in the intensity.

(either by wind, or the electrical charges), affecting condensation, cloud formation, latent heat release, the local conductivity of the global electric current, and related processes.

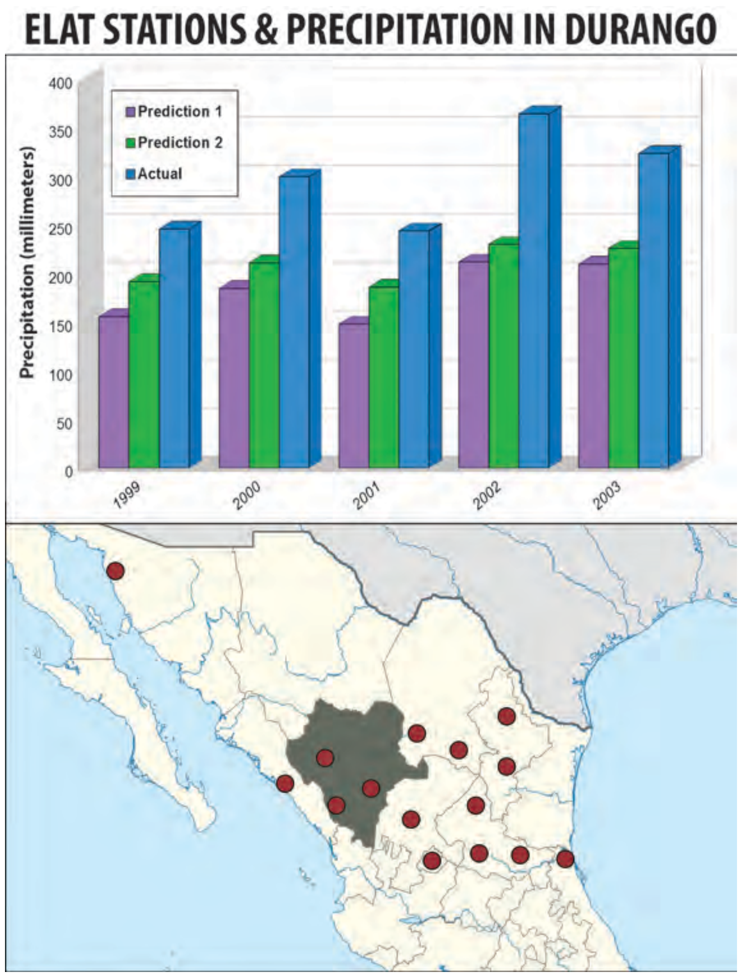
In Mexico these systems have been successful for years, with dozens of stations set up to increase rainfall in key regions starting in the mid-1990s. These Mexican systems have been based on technology that originated in Russia, where it has also been successfully used (to increase the crop harvests in the Krasnodar region, for example).[9] More recently, the United Arab Emirates has built similar systems, and a series of trial stations have shown positive results in Australia. While there have been more successful demonstrations in other nations, these three publicly available cases serve to make the point.

Case Study: Mexico

In the 1990s then-director of the National University of Mexico's Space Research and Development Program, Dr. Gianfranco Bissiachi, began a collaboration with a Russian scientist who had worked in weather modification since the 1980s, Dr. Lev Pokhmelnykh. Supported by Heberto Castillo, then-president of Mexico's Senate Committee on Science and Technology, in 1996 Pokhmelnykh and Bissiachi oversaw the development of an initial network of three ionization stations based upon Pokhmelnykh's designs (ELAT).[10] The initial results generated enough interest and support, that the system was expanded from three stations in 1999, to 21 by 2004.

In 2003 Mass High Tech ran an article discussing the potential use of ionization systems in the United States, based upon the precedent set in Mexico. They describe the success of the first Mexican ELAT ionization station as follows,

> That country's first ELAT station, in the drought-stricken state of Sonora, increased average rainfall from 10.6 inches to 51 inches in the first year, according to Mexican department of agriculture statistics. When a lack of state funds shut down the station the following year, area rainfall measured 11 inches. In the third year, with the station operational again, the area recorded 47 inches of rainfall. [In 2003 the technology was operational] in eight states in the driest regions of Mexico, and some areas [reported] a doubling or tripling of annual rainfall.[11]



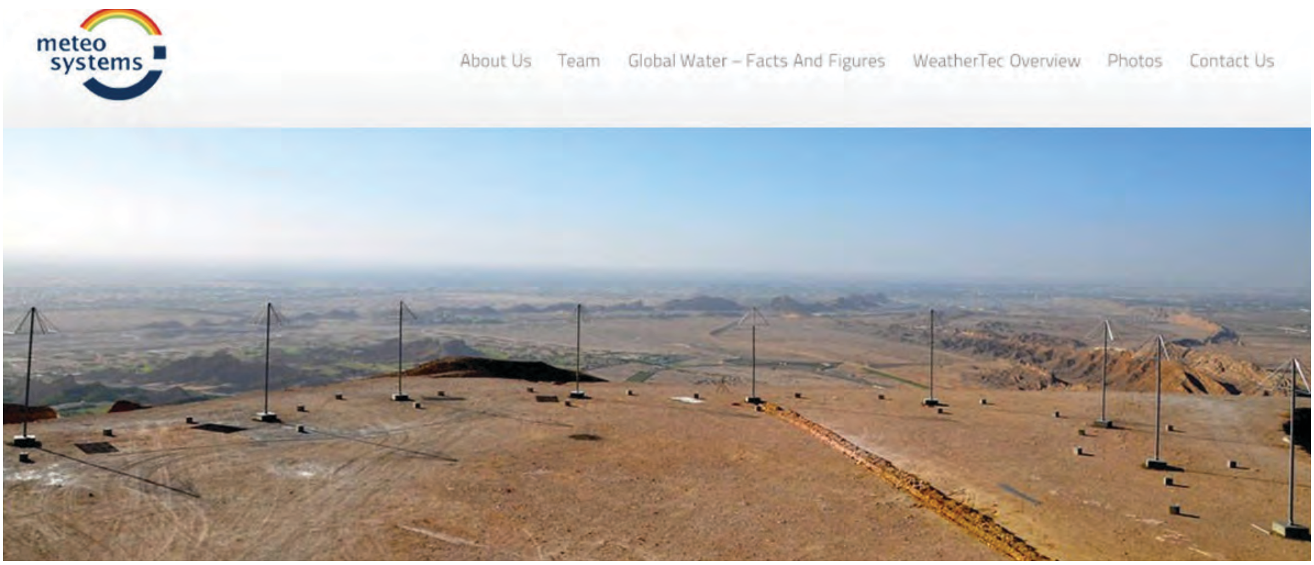
Data from "Artificial Atmospheric Ionization: A Potential Window for Weather Modification," Kauffman and Ruiz-Columbié, 2008. Mexico Map: Wikimedia Commons user NordNordWest

Figure 3

Top: Actual precipitation compared with two forecasts of expected precipitation based on historical records, for the central and southern regions of the Mexican State of Durango.
Bottom: Locations of ELAT ionization stations throughout Mexico (as of 2002), and identification of the state of Durango.

In 2004, *IEEE Spectrum* also covered these Mexico operations, citing a doubling of the average historical precipitation in Mexico's central basin, resulting in a 61% increase in bean production in the affected areas. There Bisiacchi is cited as saying that each station can affect weather up to 200 kilometers away.

A 2008 paper on the potential use of these ionization systems in Texas analyzed the rainfall levels in the central and southern regions of the Mexican state of Durango, which had benefited from these systems for a decade. Each year from 1999 to 2003 showed a significant increase in rainfall over the expected levels. The authors of the paper calculated that there was less than a one in 400 billion chance that this could have happened by chance.[12]



Meteo Systems

Figure 4
Meteo Systems website, including a picture of the Jebel Hafeet ionization station in the UAE.

According to the 2008 paper, following the successful demonstrations accomplished by 2004, a meeting was held to discuss the technology with representatives of seven federal agencies and of the nine states in Central and Northern Mexico which were using or planning on using the technology. This resulted in further support, including from the Mexican Council on Science and Technology, to fund the continued expansion of the network to 36 stations by 2006. According to another report, these systems have been so effective that they have also been used to put out fires over large areas of the Yucatán Peninsula.[13]

Before passing away in 2006, Bisiacchi expressed an optimistic vision for what mankind could do with such systems, "One of my dreams is some time to be able to go to Africa and stop the advance of the Sahara desert."

Case Study: United Arab Emirates

In early 2011, a barrage of media reports covered a leaked, supposedly secret weather modification program of the United Arab Emirates. The story broke when the UK Sunday Times detailed a contract for a Swiss company, Meteo Systems International, to build a series of ionization stations to bring rain to regions of the UAE, including the capital, Abu Dhabi.[14]

The initial coverage claimed evidence for successful operations, pointing to 52 unanticipated rain-showers, and citing interest from numerous scientists involved. However, the level of publicity apparently spooked some people, and the head of Meteo Systems, along with other scientists involved in analyzing the project, refused to speak about it, while subsequent media coverage was filled with "skeptical" reports, insisting such systems could never work.[15]

Still, the publicity generated some interesting coverage. National Geographic consulted Peter Wilderer, of the Technical University of Munich, who provided some useful background, saying, "ionization technology was first mentioned in 1890 by [Nikola] Tesla. In 1946 General Electric executed some field trials under the leadership of [Bernard] Vonnegut. Later the technology was used for military purposes in the former Soviet Union." Wilderer cited evidence he'd seen from radar images, suggesting that ionization can generate some effects, but he couldn't personally attest to the work of Meteo Systems.[16]

After the publicity died down, in 2012–2013 Meteo Systems redesigned and opened up their previously private website, which now provides explanations of their work, locations where they are trying the technology, images of the systems, and assessments of what conditions are required for them to work.

According to their website, the company was started in 2004, ran trials in Switzerland in 2005, and then started trials in the United Arab Emirates in 2006, and Australia in 2007, before getting funding from Sindicatum Sustainable Resources for an additional trial in Al Ain, UAE.

Case Study: Australia

In 2007 the Australian Rain Corporation was formed with Meteo Systems as the major shareholder. In 2007–2008 the Australian Government's National Water

Commission funded some initial trials, and in 2008 the corporation split off from Meteo Systems, and became Australian Rain Technologies.

From 2008 to 2010, Australian Rain Technologies ran three trial programs which included detailed statistical studies analyzing the effects:

- Paradise Dam, Bundaberg (January–May 2008) – Resulted in a 17.6% increase above anticipated rainfall in a 30 degree downwind arc from the system.
- Mt Lofty Ranges, Adelaide (August–November 2008) – Produced an increased rainfall of 15.8% above the anticipated levels over a 120 degree arc downwind from the system.
- Mt Lofty Ranges, Adelaide (August–December 2009) – Generated an increase of 9.4% over an area roughly twice the size of the previous trials.[17]

The company has emphasized transparency of their data and evaluations, with an open access policy, and conservative, but statistically robust, estimations of the increased rainfall. In 2011 the company submitted a proposal to the Standing Committee on Regional Australia (of the Australian Parliament) requesting $11 million to construct a series of 14 ionization stations distributed around two catchment areas in south-eastern Australia (Gwydir River and Hume-Dartmouth Rivers) to increase the rainfall going into the irrigation systems of the Murray-Darling basin (one of the most significant agricultural areas in Australia, which is facing a major water shortage—largely imposed on the basis of environmentalist-imperial policies).

They have extensive documentation available on their website.

No Limits to Growth

Rainfall is not "created" from nothing. Ionization-based weather modification actually follows the same principle as NAWAPA.

As discussed in the opening, the Sun is constantly working to evaporate massive amounts of water. On average, 280 cubic miles of water evaporate into the atmosphere every day. Since the atmosphere generally holds around 3,000 cubic miles of water, on average the same amount that evaporates must also fall back down—bringing 280 cubic miles (about 1 billion acre feet) of water down onto the Earth every day.

Since the Earth's surface is mostly water, the majority (77%) of the rain falls over the oceans, meaning most of the Sun's work producing fresh water goes to nothing!

Water is most productive when it participates in human economic or living processes, as in the photosynthesis of plant life.

However, of the total fresh water on the planet (which is only 3.5% of the total water, the rest being the salt water of the oceans), only 0.003% is actively participating in living systems (that is only 0.0001% of the total water). As it fuels the entire biosphere, this water is the most productive of all, directly participating in the anti-entropic process of life.

In first order, we must increase this percentage. But this is not the only metric to measure the productivity of the water cycle.

In a region dense with life, water will participate in plant life, evaporation, and rainfall multiple times before returning to the oceans. Plants themselves will release large amounts of water through their leaves in a process called evapo-transpiration—in addition to pulling liquid water from the soil to utilize for photosynthesis, plants also release water into the air in vapor form, from where it can fall back down as rain for more plants to then do the same.

Water is simply more active where there is plant life. The biological productivity of a region could be measured by the rate and concentration of this cycling—a hydrological flux density, if you wish—and mankind must work to increase this productivity of the North American water cycle as a whole.

NAWAPA does not "use up" more water, it directs existing water cycles towards greater participation in photosynthetic, biological, and economic processes. The original source is as continuous as the heat of the Sun—it is in the process of allocation, and resulting levels of productivity, that the power of man's hand is desired. With NAWAPA, we are not just bringing water to dry regions of the West, we are creating this entire hydrological cycle. We are increasing the hydrological flux density of the western regions, generating more green plant life, bringing moisture to the air, drawing in more moisture, and creating cooler climates in these regions to be blessed with life-giving water.

Ionization systems designed for weather modification can work towards the exact same principle.

The Pacific Ocean and Gulf of Mexico provide the atmosphere with an immense amount of water vapor. If we take the area of the Gulf and a quarter of the area of the Pacific, it is about 8% of the planet's total surface area. Assuming we could say that this would then contribute 8% of the total evaporation, we would conclude that the resulting 23 cubic miles of evaporation per day from the Gulf and one quarter of the Pacific is much greater than the total freshwater runoff for all of North America (5 cubic miles per day)—let alone the freshwater runoff from the Southwest of the continent (0.026 cubic miles per day).

Admittedly this is not a precise calculation, since the water does not evaporate at the same rate across the entire globe, and the evaporated water does not distribute itself homogeneously, as we saw with the atmospheric rivers discussed above. However, this back-of-the-envelope calculation serves to provide an order of magnitude concept of what we are dealing with: the daily evaporation from the oceans surrounding the Western and Southern regions of North America is comparable with, and likely much greater than, the existing river runoff of the entire continent, providing an incredible source waiting to be tapped!

As with NAWAPA—where we encourage some of the rain which falls in a very small coastal region of Alaska and Canada to come down into the West and participate in photosynthetic, biological, and economic processes a few times before returning to the sea—so with weather modification we can entice some of the rain that falls over the oceans to instead fall over land, and do something productive.

A Proposal

Because this is being discussed in the context of the immense crisis facing American water systems and food production, there should be no question that it deserves further investigation.

As indicated in independent case studies, ionization systems could bring more rainfall to the regions of North America where it is desired, and the relatively small size and cost of such systems means they could become operational relatively quickly and integrated with a nuclear powered NAWAPA XXI system—giving mankind revolutionary control over continental water cycles and levels of productivity never before achieved.

To do this, an assessment of the entire atmospheric-hydrological system of the Pacific Ocean and North American continent should be made, including (but not limited to) wind patterns, atmospheric rivers, continental geography, ocean evaporation rates, existing and future irrigation and water management systems, rivers, and future water requirements. This should result in a proposal for how many stations would be needed and where they should be located.

The biosphere alone has already done as much as it can. Only mankind can now act to increase the productivity of the entire water cycle and territory of North America, as measured in a greater percentage of the water cycle participating directly in living processes, and in an increasing density of participation and re-participation per unit time and per square kilometer of the total area.

The fresh water and healthy meals of millions now depend upon unleashing the full scientific power of mankind, to fulfill its intended role as the keeper of an improving biosphere.

Endnotes:

1. See the full report, NAWAPA XXI, and extensive video and written background material at http://larouchepac.com/infrastructure

2. See the LaRouche PAC feature film, *NAWAPA 1964*, http://larouchepac.com/nawapa1964.

3. See the following articles by Marcia Merry Baker: "Defeat London's Biofuels Genocide Policy Now!" (*EIR*; June 28, 2013; http://www.larouchepub.com/other/2013/4026biofuels_genocide.html), "Anti-NAWAPA Water Policy Means Food Emergency" (*EIR*; May 31, 2013; http://www.larouchepub.com/other/2013/4022anti_nawapa_food.html), and "Food & Agriculture Crisis Fact Sheet: Restore National Sovereignty, End Famine-Depopulation Agenda"(*EIR*; February 22, 2013; http://www.larouchepub.com/other/2013/4008food_ag_crisis.html).

4. http://tenaya.ucsd.edu/~dettinge/atmos_rivers.science.pdf

5. Correlations between solar activity and weather / climate had already been long documented, but with no satisfactory explanation for how the interaction occurs. Because the Sun (through its magnetic field) modulates the galactic cosmic radiation reaching the Earth, Pudovkin proposed that it was actually the cosmic radiation that was affecting the Earth's weather / climate, and the correlation with the Sun was due to the role of the Sun in affecting how much of the cosmic radiation reaches the Earth.

6. "Solar Activity and Cosmic Rays: Influences on Cloudiness and Processes in the Lower Atmosphere (in Memory and on the 75th Anniversary of M. I. Pudovkin)," by O. M. Raspopov and S. V. Veretenenko. *Geomagnetism and Aeronomy*, April 2009, Volume 49, Issue 2, pp 137–145.

7. More clouds will reflect more sunlight, and cool the climate. See, *The Chilling Stars: A New Theory of Climate Change,* by Henrik Svensmark and Nigel Calder. Totem Books, March, 2003.

8. While there are honest questions, the intensity of the debate—and, more importantly, the intensity of the desire to dismiss the investigation all together—is fueled by its impact on the Anglo-Dutch empire's flagship lie: anthropogenic global warming.

9. See, "Weather Control? Yes, it is Really Possible," by Sergey Pulinets. *Russia Beyond the Headlines*, March 25, 2009. http://rbth.ru/articles/2009/03/25/250309_weather.html

10. In the early 1990s, after the fall of the Soviet Union, Pokhmelnykh started a company, Electrificación Local de la Atmósfera Terrestre SA (ELAT), based upon his weather modification techniques. See, "Rain, Rain, Go Away, Go Soak Someone Less Willing to Pay: Moscow Firm Offers Weather Made to Order (October 2nd, 1992, *Wall St Journal*, by Adi Ignatius); "Out of Russia: For a Price, Even Weather is up for Sale" (October 9th, 1992, *UK Independent*, by Andrew Higgins); and "Russian Scientist – Mexico's New Rain God?" (June 24th, 1996, Reuters).

11. "Looking for a Change in the Weather?" by Jay Rizoli. March 10th, 2003, *Mass High Tech: The Journal of New England Technology.*

12. See, "Artificial Atmospheric Ionization: A Potential Window for Weather Modification," by Phillip Kauffman and Arquimedes Ruiz-Columbié, 2008.

13. See note 9.

14. "Looks Like Rain: Science Creates Downpours," January 2nd, 2011, by Rod Chayto and Jonathan Leake, *Sunday Times*.

15. For example, see, "Rumors and Rainmaking in Al Ain," by Jonathan Gornall. *The National* of UAE, February 3rd, 2011.

16. "Scientists Make Dozens of Storms in the Abu Dhabi Desert? Claims of Manmade Rain Clouds Spark Skepticism," by Brian Handwerk; *National Geographic*, January 18th, 2011.

17. "Australian Rain Technologies (ART): Briefing to House Standing Committee on Regional Australia on trialling the potential contribution of ART's Atland rainfall enhancement technology in the Murray Darling Basin," January 2011. See, "Appendix B: Results from four Australian trials." www.AustralianRain.com.au/Assets/Files/PDF/110323_RAC-submission.pdf

The Physical Profit of Planetary Defense

by Jason Ross

Jason Ross delivered this presentation at an April 2013 Schiller Institute conference held outside of Frankfurt, Germany. The video presentation is available at newparadigm.schillerinstitute.com.

I am very happy to follow the excellent presentation of Mr. Benediktov on planetary defense, on the Russian proposals for international cooperation. He covered many of the technical aspects and the threat of asteroids very well.

What I would like to focus my presentation on today, is Mr. LaRouche's economic outlook, which underlay his initial proposal for the Strategic Defense Initiative (SDI). Mr. LaRouche's view, of human creativity as the fundamental source of economic wealth, and of being able to consider a global measure of economic value, as opposed to an addition of local economic values, saw the buildup of the SDI not as a cost, not as a burden, but as a source of great economic profit. Think how different that is from the current U.S. anti-missile system, which has a cost, is expensive, but provides no great spin-off technologies, as the Strategic Defense Initiative would have.

So let me discuss the concept of *energy-flux density that* Mr. LaRouche referred to. He did not propose kinetic kill vehicles in the proposal made in the 1980s, but instead the use of "new physical principles," including breakthroughs in laser and particle beam technologies, as well as fusion. Now, while there were advancements in anti-missile systems, these were *not* the SDI.

We heard about some of the developments in the anti-missile system at our last Schiller Institute conference in the United States, but this did not represent the intention of the SDI, or the Strategic Defense of Earth, now. The purpose of the SDI was not only defense against missiles, but for political cooperation with the Soviet Union—which the U.S. is not pursuing with its anti-missile system, in regards to Russia—and, for the spin-off technologies and the economic profit that it would bring. It would be similar to, but much greater than, President Kennedy's mission to go to the Moon. The Apollo program had a large cost, but it had zero net cost, a negative net cost because of the benefits that came from the technologies.

In the case of the Strategic Defense Initiative, and the need today for technologies for Strategic Defense of Earth, including the necessity of fusion, the developments will not only be technological, but scientific as well. This has a very great potential.

Energy-Flux Density

So, what is energy-flux density? There is a problem in applying scalar metrics, where we use one kind of ruler to understand many different processes. For example, economists, who study the economy in terms of "money," are never actually studying the economy. Or, if you look at physics, there is a unit of "energy." There is something real about energy, but there is an understanding that is lost when we consider purely energy itself. Rather, with the concept of energy-flux density, we begin to look at the *quality* of sources of power, not only the quantity.

Now, by the *quality* of power, I don't mean a fancy Swiss watch—I mean the opposite of quantity. So, for example, if you have a scientist who studies rocks, he's used to dealing with mass, density, perhaps temperature, electrical conductivity; if he were looking at a dog, he isn't even considering many of the things a veterinarian would look at, such as heartbeat, metabolic rate, nutrition. A pure biologist could not understand human beings; without a concept of culture, a biologist might try to cure all social problems with medicines, instead of changing the culture in which people exist, or their thoughts.

So, from the standpoint of physics, from the standpoint of economics, energy-flux density is crucial for understanding the different sources of power.

For example, if we use muscle power, whether human muscle power, or the muscle power of an animal, it's very limited, and it consists in mechanical motions. With the use of burning coal to create a steam engine, yes, we still make mechanical motions, but they're much more powerful than what could be done by, say, a horse. With the use of electricity, you can measure electrical power, in terms of horsepower as a physical unit, but electricity does so many things you cannot do with an animal. I think we can all think of many examples: There's nothing you can do with a horse that can make the headphones we're wearing, work. It's a different kind of power.

With fission power, and then especially with fusion power—if we develop fusion, the benefit will be that electricity will be almost free; the other benefit is that new qualities of economic activity are possible. Take, for example, the ability to use a fusion torch for recycling purposes, to break down material into its elements, in a similar way that we break down petroleum products into different products now.

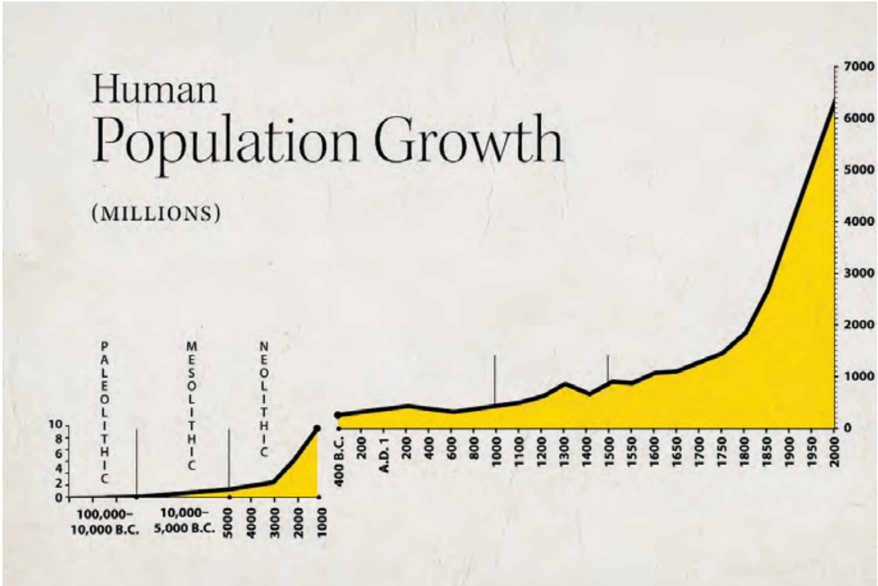


Figure 1

Human population on a historical scale. Would a population-chart of any other species appear similar? What is the cause of the unique change in potential population of the human species?

For the SDI, or the SDE, we need, as a source of power, fusion; we will not be able to move asteroids with windmills! We cannot use mirrors to take the solar power to move an asteroid. We're not going to do it by returning empty soda bottles for 15 cents. This outlook of humanity will not defend us against an asteroid. And currently, fusion power, at least in the U.S., is funded far below the funding for stupid solar panels—it's ridiculous. We could completely change our relationship to the physical world by the development of fusion power, which would change our relationship to materials, for example.

Potential Relative Population Density

To apply this to human economy, Mr. LaRouche has used the concept of *potential* relative population density. So, the potential population density, in a certain area: How many people *could* live there? What is the potential? How has that changed over the years? If we look at this chart (Figure 1), of European population, over the past centuries and several millennia, we see a dramatic increase in the number of people that are able to live here. This is not because people are having more babies; it's not for reasons like that. It's that, as we transform as a species the way that life does as a whole in evolution, we really do become like a new species, when we have a new platform of scientific development to stand on.

When life moved from the oceans to land, it dramatically began to increase its power on the Earth. We do the same thing when we develop new sources of power, for example, for agriculture, or the study of medicine.

This is something that's very natural for human beings. It would be *unnatural* for us *not* to continue this trend. That would be like a reptile saying that a mammal is "unnatural." Or, it would be like a rock saying a lizard is "unnatural." The rock says, "Hey! I'm just sitting around here, and you're moving, you're walking on top of me, you're sitting on me. You know, I don't enjoy this, it's unnatural." But lizards aren't rocks, and human beings are not animals.

So, compare different cultures today: As was just discussed, China today has some ambitious programs. They have a three-phase lunar program that they began several years ago. Phase two will land devices on the Moon. Phase three is to bring back material from the Moon, something that, until now, only the United States and the Soviet Union have done. India is moving forward: They sent a probe to the Moon in 2008. They plan to send a satellite to Mars this year, which will make them the third nation to do so.

We just heard a great deal about Russian proposals for international cooperation on missile defense, which, yes, if we're using nuclear weapons, it absolutely must be international—and it must involve civilian and military aspects, something that NASA must understand.

And in the U.S., NASA has a mission to land a man on an asteroid by 2021. This is a joke. Nobody really takes this seriously. There's really no point in standing on an asteroid. You would probably need special boots to do it, because the gravity is so small on an asteroid, that if you sneeze, you will fly off of it! In fact, right now, with the sequester in the United States, NASA scientists can't even go to meetings anymore! They can't go to conferences! So, right now, NASA can't send a man to the Moon, NASA can't send a man to Mars; they can't even send a man to Paris, Berlin, or Tokyo for a conference!

The 'Basement' Science Project

So, we must have a total shift in our activities and our priorities, and we also have to have a revolution in how we practice science. I want to say something very briefly on this: Mr. LaRouche's "Basement" project has taken up a study of the internal history of science, going back to the first modern scientist, Kepler, up through Fermat, Leibniz, Gauss, Riemann, Planck, Einstein, and Vernadsky. I will show you briefly, one very amazing result that came from some of our studies.

What you're about to see here is, you're seeing these rings appear. What the animation[1] is showing, is, in each frame of the video, all of the dots that make it up are the centers of the orbits of various asteroids. And we're choosing the asteroids based on their average distance from the Sun. Here, they'll be drawn in, as we're moving farther from the Sun.

Now, there's not enough time to fully discuss this, but taking the approach of Kepler and Gauss, that there must be a reason for why the universe is so, and not otherwise, from the standpoint of Leibniz, who said: Yes, God is completely powerful, but He is also so wise, that he does nothing without a reason.

We decided to apply this approach—Kepler's method—to the asteroids, to start trying to look at the asteroids, as a system, to look for a structure in the Asteroid Belt. The swarm of asteroids that Mr. Benediktov discussed, where they seem to come in a greater number all at once: Why is this? If we have a hypothesis about the structure of the asteroids, maybe this will make it much easier to find them; maybe this will change our view of how to move them.

So this is something that the LaRouche Research Team is discussing, and we're starting to confront NASA scientists with this, who are trying to figure out—no one has seen this before. So this is a new observation. Kepler would be very happy.

A Wonderful Gift to the Future

Let me say, to conclude here, that the path to that is offered by the SDE concept of the common aims of mankind; this allows us to give a very wonderful gift to the future. In one generation, or more like two generations, as some of the first visitors and perhaps settlers to the Red Planet, to Mars, are taking their one-week trip to get there on a fusion rocket, they might wonder how foolish we were, in the beginning of the 21st century, to confuse banks for the real economy, or why we were so fixated on using *less* energy, instead of developing better sources of new energy? Or why we separated our trash into fifteen different colored bags, instead of recycling it with fusion?

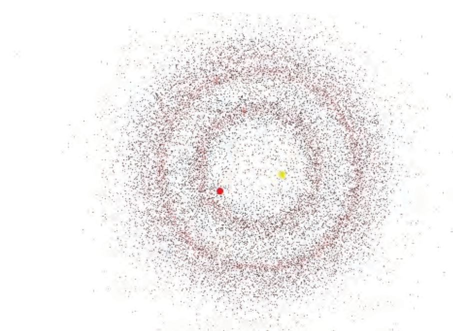
Mrs. Zepp-LaRouche was telling me the other day about a report she had read, that German youth are among the least happy, but it is not because of physical poverty. I think a large part of it comes from the omnipresent Green outlook, where children are taught that they are disease on the planet—you know, "you are a cancer"; that the best possible role for your life, is to not exist! To have no impact on the world—you come, you go; it's as if you were never there. That's not exactly an optimistic outlook!

Compare that with a mission to go to Mars, to discover new sources of power, to master matter-antimatter. And I think what we can do, is really give a wonderful gift, because the greatest gift that a nation, or a culture, can give to its members and its future members, is the knowledge that those people lived lives that were not only good and useful, but in fact, *necessary* for the future.

We have to have a direction, that we're moving to where people are necessary, and not burdens that we should euthanize when they reach 70 years of age. So, by adopting this SDE approach, the new technologies needed for planetary defense, and getting Glass-Steagall and a credit system immediately to make it possible, I think we are giving the future a very wonderful gift!

Thank you.

A written report on the asteroid research is available at: http://schillerinstitute.org/conf-iclc/2013/0413_frankfurt/AsteroidUpdate.pdf. The observed rings correspond to the "proper" orbital elements of asteroids, as their orbital elements are extrapolated into the future.



One frame from the cited animation. Rings are formed by the centers of asteroids whose semi-major axes lie in a certain range. Why is this?

1. http://www.youtube.com/watch?v=uWXmyS30Eqk

To Save the Nation, Restore the American System

by Marsha Freeman, Michael Kirsch, Matthew Ogden, and Jason Ross

A great hoax has been perpetrated upon the people of the United States, and you, yourself, may have fallen victim to it: that it is money that runs the economy; that there is not enough money to fund the critical functions of government, even though they are guaranteed under the Constitution; that in order to fund what are considered priorities, other necessary programs must be cut; that balancing the federal budget is a necessary underpinning of monetary and economic policy, and will restore economic growth; that citizens must bail out bankrupt banks, because without them, we will not have enough money to run the economy; that it is the "free market" that is the foundation of this nation's economic power.

Not one of these propositions is true. In fact, if any one of them were, the United States would never have become the greatest industrial and agricultural power on Earth, much less put a man on the Moon.

The economic crisis facing this nation is virtually unparalleled in our history. But contrary to popular opinion, there is no shortage of "money." Trillions have been siphoned from the federal Treasury to bailout bankrupt, criminal financial institutions. Trillions are being spent to service illegitimate debts, held by towns, cities, counties, and the federal government, a result of rigged credit ratings, rampant speculation, commodity price manipulation, and outright theft. And, as a consequence, entire cities, industries, farms, hospitals, and schools are being shuttered.

The shortages the nation *actually* faces are in food production, energy, productive employment, adequate health care, great infrastructure projects, and science-driven breakthroughs in new technologies, which will lay the basis for future prosperity.

Were this nation to continue on its present path, what awaits us is what is already evident in Greece, Cyprus, Spain, Portugal, Italy, and an increasing number of European nations: a collapse in employment; the pauperization of an increasing portion of the population; food "insecurity;" lowered life expectancy and falling birth rates; increases in preventable disease; and social disintegration, including dramatic increases in rates of crime and suicide. Today, entire nations are facing outright extinction.

Had the American founding fathers followed the policies of financial control by European oligarchies, which had spurred the very movement to leave the Old World and create a "New World" across the ocean, this nation would have remained a jewel in the crown of the British Empire. In contrast, thanks to the brilliance of our first Treasury Secretary, Alexander Hamilton, the debts incurred that enabled a colonial victory in the fight for our independence from the British Empire did not bankrupt

Library of Congress

In 1792, Alexander Hamilton helped establish the city of Paterson, New Jersey, through the Society for Establishing Useful Manufactures. This new city was centered around the potential water power from the Great Falls along the Passaic River. Mills along the river produced cotton fabrics, and manufacturers built factories that produced railroad locomotives, textile machinery, Colt revolvers, and later, aircraft engines. This industrial park was envisioned to help bring an industrial revolution to the new nation. This aerial view shows the buildings of Allied Textile Printers.

the new nation. The debt was reorganized and subsumed under a federal credit system that produced decades of explosive growth in the physical economy. Only on the basis of increasing real physical wealth could legitimate debts ever be repaid. And contrary to the myth that what has made this nation prosperous is the "free market," economic growth could only materialize with a federally-directed deployment of resources to bring more advanced capabilities to bear on agriculture and industry, increasing the productivity of labor of the entire economy.

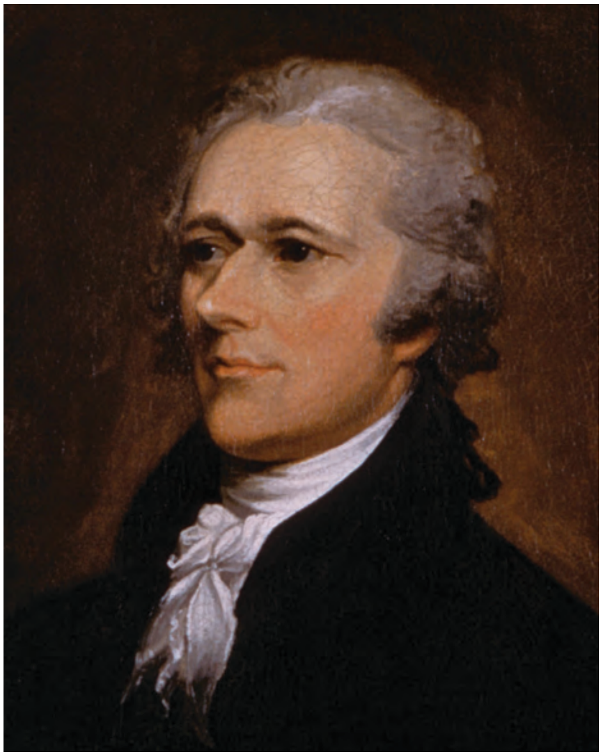
The choice today could not be more clear. Austerity—trying to "balance the budget" by cutting spending for critical social needs, such as health care, education, and pensions—in the short term will prematurely end the lives of our most vulnerable citizens: the elderly, the poor, children, and the infirm. In fact, cutting programs and shutting down towns and cities in order to "save money" to repay debt will only make the crisis worse, by undercutting the very investments that would "grow" the country out of the depression.

Federal credit, vectored toward immediately reversing the increasing penury of the citizenry, initiating great infrastructure projects to restart industry and reemploy the population, and directing the nation's talent and resources to create a future that looks even beyond Earth to the stars, is the alternative.

This not a theoretical economic approach that has never been tried before. It was the foundation of the national banking system created by the nation's first Treasury Secretary, which established the United States as an independent nation. It was restated by President Franklin Delano Roosevelt to reverse the Great Depression. It has been the underlying principle for every period of economic growth, from our founding.

Economic policy is not a set of rules and regulations; it defines the moral compass of the nation. If the United States continues on its current path, it will demonstrate that we do not have the moral fitness to survive.

It is time for everyone to relearn American history.



Alexander Hamilton, (c.1755-1804), the first Secretary of the Treasury of the United States

The First National Bank of the United States

Return to Hamilton's Credit System

Our country was built on the principle of national credit in the 1680s, even before we gained political independence. The Massachusetts Bay Colony had established economic sovereignty from European monetarism by means of the Pine Tree Shilling, a credit vehicle which allowed the republican colonial government to finance the physical economic development of the new territory, creating a rapid expansion of farm cultivation, industry, and other manufactures, including the unparalleled success of the Saugus Iron Works.

Although these early bold experiments were crushed with the suppression of the colonial charter after William III's usurpation of the throne, the legacy of Massachusetts Bay found its voice in Benjamin Franklin, the father of the American Revolution. Franklin's early advocacy of paper money tied to productive credit, laid the groundwork for his later leadership in the fight against British repression of American industry and manufactures. The post-1763 Navigation Acts and countless other pieces of legislation, which not only imposed exorbitant taxes on the American people, but had the primary purpose of enforcing a permanent state of colonial backwardness in the territories of North America, laid the groundwork for the American Revolution. Forged in the fires of that war, a new generation of leaders received their education in the republican economic principles as understood by Franklin and others, so that, upon securing political separation from the British Empire, the young genius Alexander Hamilton was poised to substantiate that political independence-in-name, by securing America's economic independence-in-fact, by means of the creation of a national credit system.

The U.S. credit system is not an optional feature, or an add-on to the Constitution. Rather, the need for a credit system to drive the economic growth of the new nation as a whole was the chief driving cause for the creation of the Constitution, as a replacement for the weak Articles of Confederation. National sovereignty meant not only the ability to repulse foreign aggression and maintain national borders; it required the establishment of an economic system capable of ensuring the continuing development of the people of the nation, by fostering the increase in the productive powers of labor, through a national bank.

Already in 1781, before the conclusion of the Revolutionary War, Hamilton wrote to Robert Morris, Superintendent of Finance for the Continental Congress, describing his idea:

> The tendency of a National Bank is to increase public and private credit. Industry is increased, commodities are multiplied, agriculture and manufactures flourish, and herein consists the true wealth and prosperity of the state. It turns the wealth and influence of both parties into a commercial channel for mutual benefit, which must afford advantages not to be estimated; there is a defect of circulation medium which this plan supplies by a sort of creative power, converting what is so produced into a real and efficacious instrument of trade. It is in a National Bank, alone, that we can find the ingredients to constitute a wholesome, solid and beneficial paper credit.

At the conclusion of the Revolutionary War, the newly established nation was bankrupt. Much of the physical economy of the colonies had been destroyed by the fighting, and both the national government and the States were mired in debt. The interest alone on the total debt amounted to more than the entire revenue projected to be available to the Federal government. The debt, on top of the physical destruction, provided a grim prospect for the newly independent nation, posing the immediate threat of disintegration, or even reconquest. It was impossible, under the insufficient powers granted to the Congress in the Articles of Confederation, to establish a credit system, to promote a growing, national economy, which could make good on the debt. Robert Morris, Alexander Hamilton, James Wilson, Gouverneur Morris, Benjamin Franklin, George Washington, and other founders had a shared commitment: a new constitution was required, one that gave the national government sufficient power to accomplish the aims set out in the Declaration of Independence.

Using the powers of the new Constitution, Hamilton put into practice his concept of credit, which served to solve the seemingly insoluble crisis. He devised a plan to put into motion the active capital of the nation's land and industry, by creating a financial system and currency based on future productivity, rather than money and monetary debts.

Hamilton engineered the transfer of the various colonial debts onto the federal books, unifying it into a single national debt and simultaneously creating the possibility of its retirement by connecting it to physical investment. Debt was redefined, therefore, not simply to be paid back in money, but as a process by which investment in the future created new sources of wealth, and with it the means to retire that investment—in other words: debt to the future, as opposed to debt to the past. By turning this national debt into a pool of capital against which to invest in building up the physical economy, Hamilton turned what would have been a curse, into a blessing.

Hamilton's system established the principle that value in the economy would be based on the productivity generated by future payments on credit, rather than cash payments up front. The intention of Benjamin Franklin for a paper currency equal to productive trade was now

The Erie Canal, under construction across New York State between 1817 and 1825, was one of the great infrastructure projects promoted by Hamilton's National Bank's credit policy for "internal improvements." The Canal, connecting the Port of New York to the Midwest's Great Lakes, was the first transport route to the western interior of the country. It cut by 95% the cost of the transport of goods as compared to carts pulled by draft animals.

actualized by the credit currency of the Bank. The essential principle of credit is not the use of paper notes instead of a currency of gold and silver, but rather a unification of the productive powers of the economy to support the currency, such that the currency becomes a reflection of future growth.

Reflecting on the system he had constructed, he wrote in his *Report on a Plan for the Further Support of Public Credit* in 1795:

> Public Credit... is among the principal engines of useful enterprise and internal improvement. As a substitute for capital, it is little less useful than gold or silver, in agriculture, in commerce, in the manufacturing and mechanic arts... One man wishes to take up and cultivate a piece of land; he purchases upon credit, and, in time, pays the purchase money out of the produce of the soil improved by his labor. Another sets up in trade; in the credit founded upon a fair character, he seeks, and often finds, the means of becoming, at length, a wealthy merchant. A third commences business as manufacturer or mechanic, with skill, but without money. It is by credit that he is enabled to procure the tools, the materials, and even the subsistence of which he stands in need, until his industry has supplied him with capital; and, even then, he derives, from an established and increased credit, the means of extending his undertakings.

In Hamilton's *Report on Manufactures,* he laid down the essential principle of economy as a physical system of productivity. The primary measure of value is not capital, but the mental powers which increase the productive powers of labor. Hamilton viewed the currency not as wealth itself, but the constitutional responsibility of government to facilitate scientific ingenuity and the spirit of enterprise.

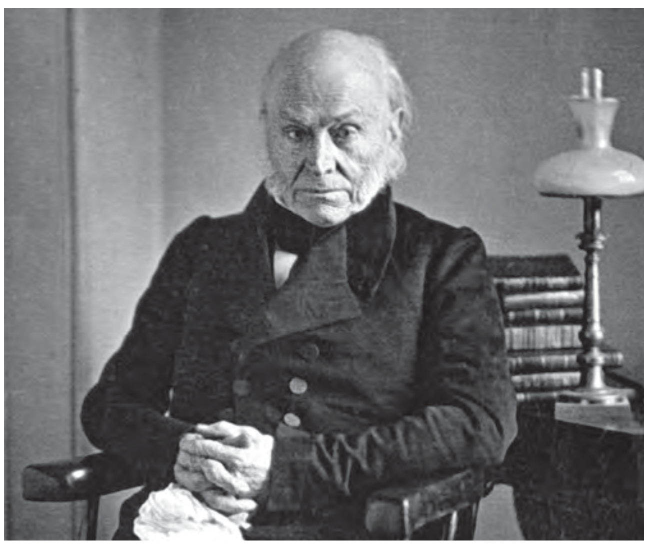
Hamilton established the meaning of the U.S. credit system as not merely a well-regulated currency with bank lending, but one in which a direct lending institution guides the economy according to the principle of maintaining a diversion of surplus and revenues toward increasing economic growth. Government debt is not to be handled as a monetary debt to be met with budget cuts, but, instead, must be tied to future income related to increases in productivity, through an economy regulated and facilitated by a national credit system. As he states: "Industry is increased, commodities are multiplied, agriculture and manufactures flourish, and herein consists the true wealth and prosperity of the state." It was this, and only this, which bestowed credit upon the paper currency of the United States.

John Quincy Adams and the Revival of the National Bank

The charter of the first National Bank expired in 1811, and it wasn't until 1816 that the Second National Bank was chartered. As a result, after the United States fought and won a war against Great Britain in the years between, the country was plagued by economic chaos. Returning to the conditions before Hamilton's measures, in the absence of a unified national currency, states began to issue multiple separate paper currencies, which rapidly depreciated in value anywhere from 5-25%. Brokers set up shop between the state currencies, and speculation ran rampant.

President James Madison accepted a design for a bank charter almost identical to Hamilton's original and signed it into law in 1816, with overwhelming support. However, the simple existence of a Bank of the United States, does not equal a national credit system, and the failure to promote manufactures after the War of 1812 resulted in a banking crash. All sectors of the economy suffered a prolonged depression until 1822, despite such useful measures as the 1817 bill passed by New York to begin construction of the Erie Canal, and Virginia's creation of a Fund for Internal Improvement and a Board of Public Works.

Economic recovery only occurred when Nicholas Biddle took the helm of the National Bank. A follower of Hamilton's concepts, Biddle assumed his post in 1823, and worked under the leadership of economist Mathew Carey to restore the nation's currency and physical productivity after the ravages of speculation. As under Hamilton's direction, Biddle's principle was to protect and nurture the economy's long-term operations, rather than allowing it to fall prey to demand for immediate pay-



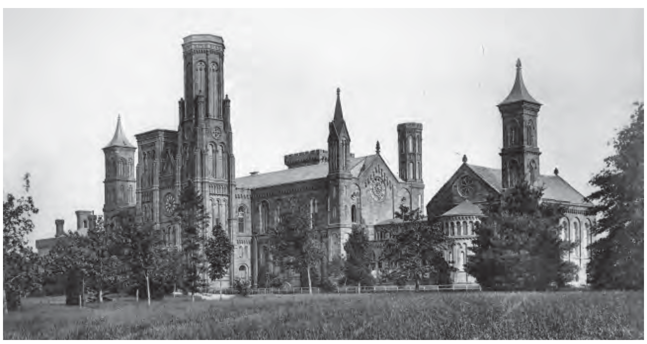
John Quincy Adams (1767-1848)

ment, particularly payment in gold or silver. The domestic economy was able to grow in relation to its potential productive power, rather than by artificial controls.

Under Biddle's tenure, the Bank fostered what would prove to be one of the most technologically explosive periods in American history. In 1824, House Speaker Henry Clay put through a protective tariff law to protect American manufacturing, along with the General Surveying Act, which authorized the use of U.S. Army personnel in the construction of civil engineering projects. With these laws in place, and Biddle at the Bank, the ground was prepared for John Quincy Adams, who was elected to the presidency in 1825.

Before 1820, there was not a single railroad, only a few canals, a collapsed iron industry, no modern factories to speak of, no steam power harnessed for industrial purposes, only wooden machines in production facilities, and virtually no public schools. John Quincy Adams' presidency changed everything.

Under the guiding hand of the National Bank, canals and roads began to be built with great speed, opening up the West to settlement. Coal mines were connected to urban areas, creating the great Midwestern industrial cities. The iron industry, under tariff protection, was reborn after over a century of suppression since the closing of the Saugus Iron Works. Thousands of miles of railroads were built, with West Point's Army engineers designing the great Baltimore and Ohio. Sixty other railroads were similarly planned and designed. Financing and planning of these enterprises was coordinated by Federal, state, and local authorities, with the Bank of the United States facilitating and directing the entire national program, coordinating both public and private funds for investment into infrastructure and industry.



Smithsonian Institution Archives

James Smithson, a British mineralogist, who in 1829 bequeathed his life's fortune to establish the Smithsonian Institution in Washington, DC, had a firm belief that this young United States held the promise of great advances in the future. Had it not been for the forceful and tireless intervention of then-former President John Quincy Adams, that fortune would have been misdirected and squandered. This photograph of the Smithsonian Castle was taken soon after its completion, in 1867.

As more agricultural land was developed, as more manufacturing facilities were established, and as more transportation networks for produce and coal for manufacturing facilities were completed, the amount of bank credit that could safely be put into circulation increased proportionally, doubling and then tripling over that decade.

Under the proper functioning of the credit system, the meaning of debt was transformed. Not simply a direct monetary obligation, the debt of states for infrastructure was paid by the future development of industries. The debt created for internal improvements, and personal debts in farming and manufacturing, were simply part of the growing economy under the credit system. The states, which had incurred large debts for canals and roads, planned to develop iron and coal industries and new transportation routes for the products of the new lands. These newly developed lands and industries along the infrastructure routes increased income up to ten times over the initial investment.

Seeing farther in to the future, John Quincy Adams personally intervened to prevent the loss of a true national treasure. In 1829, relatives read the will left by British mineralogist, James Smithson, and learned (to their chagrin) that he had bequeathed most of his life's fortune to the United States of America, "to found at Washington, under the name of the Smithsonian Institution, an Establishment for the increase & diffusion of Knowledge among men." This bequest, equivalent today to $50 million, reached these shores a few years later, but was subsequently squandered by a President, Andrew Jackson, who had disbanded the National Bank of the United States, and a Congress which tacked an amendment onto a bill, which authorized the Treasury Secretary to place the entire sum of Smithson's bequest into bonds held by bankrupt states. John Quincy Adams was furious.

In his first State of the Union address in 1825, President Adams stated that the Federal government had responsibility for the nation's culture and science. He promoted the establishment of a national university, and astronomical observatories, or "lighthouses on the skies." In 1839, now out of the White House, but holding a seat in the Congress, Adams went on a barnstorming tour, to rally public support to rescue Smithson's squandered bequest and apply it to the purpose for which it was intended. Finally, Adams succeeded in replenishing Smithson's fortune through the Federal Treasury, creating an institution which today supports scientific research, museums for the education of the public, and promotes the advancement of science, the basis upon which to create the future.[1]

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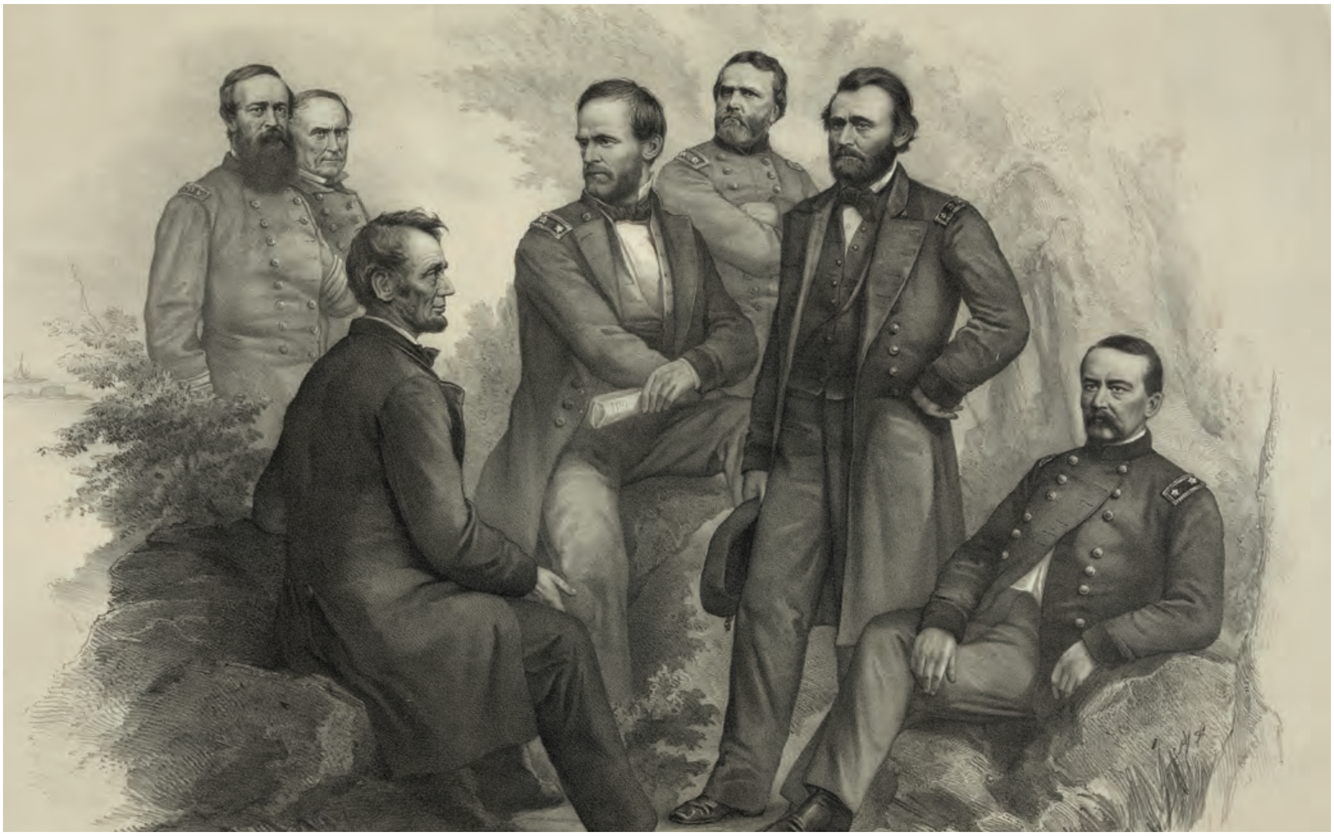
1. See *The Stranger and the Statesman*, by Nina Burleigh, HarperCollins, 2003



Library of Congress

President Lincoln and his Generals: Andrew Porter, Admiral David Farragut, William Tecumseh Sherman, George Thomas, Ulysses Grant, and Philip Sheridan.

Abraham Lincoln Saves the Nation

I presume you all know who I am. I am humble Abraham Lincoln. My politics are short and sweet, like the old woman's dance. I am in favor of a national bank, the internal improvement system, and a high protective tariff.

—Abraham Lincoln, Campaign for Illinois state legislature, 1832

By the time Abraham Lincoln became President in 1860, on the eve of the secession of the southern states, there were no less than seven thousand separate currencies circulating in the United States—a nation hopelessly divided, the constitutional federation of Hamilton all but lost. To save the Union, it was necessary to restore the system of national banking. With private bankers in New York moving to cut off flows of revenue into the Treasury by ceasing their purchase of government bonds and blocking the arrangements of foreign loans, the Treasury notes became discredited, causing a seize-up of available credit.

To outflank this financial warfare against the nation, and fund the war to save the republic, Lincoln established a new national source of credit. The Legal Tender Act of 1862 authorized the issuance of "United States Notes" (or "greenbacks") for the purpose of "funding the floating debt of the United States." With Congress's passage of this Act, the federal government reclaimed control of the national currency. Lincoln economic advisor Henry Carey made clear the relation of this policy to the former Bank of the United States, writing in 1868: "The Bank of the United States did not give us a specie currency; its notes were current almost on the same fundamental hypothesis, which has given useful circulation to the Legal Tender issues." Lincoln tripled government spending to fund the Civil War, issuing $450 million in greenbacks. Simultaneously, he moved to eliminate the thousands of separate—and often counterfeit—currencies, by means of a national banking reorganization, and the creation of the Secret Service, under the Treasury Department, to find and bring to justice the criminal counterfeiters.

A series of acts converted state banks into nationally unified, regulated entities, which allowed for the coordination of a national banking system which could issue national credit. This became the basis by which a single currency was re-established, thus restoring the Constitutionally mandated federal control over the nation's currency and finances.

President Lincoln, even while leading the Union to victory in the Civil War, focused attention on the future. To broaden the responsibility taken by the federal government for the welfare of the nation, Lincoln also created the U.S. Department of Agriculture, and the National Academy of Sciences.

NATIONAL ACADEMY OF SCIENCES
1863–2013
Celebrating 150 Years of Service to the Nation

Courtesy National Academy of Sciences

Although the entirety of his presidency was necessarily consumed by the fight to preserve the nation during the Civil War, on March 3, 1863, President Lincoln signed the Act creating the National Academy of Sciences. Tasked initially to help solve the problems arising from the new technologies developed for the War, for 150 years, the Academy has provided independent analysis and advice to the White House, the Congress, and the American people.

Franklin Roosevelt's New Deal

Lincoln's assassination was followed by the assassinations of two other nationalist presidents, James Garfield in 1881 and William McKinley in 1901. The legacy of Hamilton was once again lost, and under President Woodrow Wilson, any remaining vestiges of national banking were replaced by the unconstitutional Federal Reserve. Increasingly, long-term investment into the future development of the nation was supplanted by a culture of gambling and wild speculation. This bubble exploded in the Crash of 1929, marking the worst depression the nation had ever faced. By the eve of Franklin D. Roosevelt's inauguration, unemployment exceeded 20%, two-thirds of the states had taken emergency measures to close their banks, and industrial production was half the pre-crash level.

It was necessary for Roosevelt not merely to institute a "bank holiday" to reorganize the banks, but to establish a principle of credit, which did not exist. His administration separated those banks needed to maintain a functioning economy from those that had brought finance to a standstill through wild speculation, through the 1933 Banking Act, or Glass-Steagall. The goal was to make banks capable of operating within the new context, with a plan for "Credit Banks for Industry," which eventually became the expanded Reconstruction Finance Corporation (RFC). Roosevelt used the RFC—which had been created under President Herbert Hoover to bail out financial institutions—as a makeshift national bank, greatly expanding it, and ultimately extending the equivalent of over $1 trillion, in today's dollars.

The RFC and companion measures provided financing for the great projects of Roosevelt's day, implemented by such agencies as the Public Works Administration, the Works Progress Administration, and the Rural Electrification Administration, which together employed millions of Americans and dramatically increased our nation's productive powers through electricity, navigation, agricultural education, water projects, and transportation. The explicit purpose of FDR's Tennessee Valley Authority (TVA) was not only immediate relief for the millions in the southeastern United States who lived in abject poverty, but to create the conditions of development "for generations yet unborn."

These projects could not have been financed by taking out loans and selling bonds, in a climate of grave economic depression. Rather, the government stepped in to ensure that projects whose physical productive results would more than offset the cost of their construction, would not be held up due to the lack of available capital for their implementation. The RFC loans and TVA borrowing were repaid directly, as well as many times over, indirectly, by the increased federal income tax revenues resulting from the increase in productivity.

In order to be able to bring these great projects into being, President Roosevelt relied on the "moral conscience" of his Secretary of Labor, Francis Perkins, who accepted the job in the President's cabinet with the proviso that he carry through on his campaign promise to create a "new Deal" for the American people. Under Perkins' stewardship, the Roosevelt Administration promulgated legislation to protect the American people from the slavery of Wall Street and the "free market." She agreed with the President that there should be no "forgotten men," and under her leadership, the Roosevelt Administration created unemployment insurance, Social Security, the prohibition of child labor, the minimum wage, workman's compensation, and a legal limit to working hours. These protections would improve the conditions of an impoverished nation to be able to carry out the infrastructure projects that would reverse the Great Depression.[2]

With these tools in hand, based on the American system of economics that had crated the nation to begin with, Roosevelt achieved a functioning credit system

2. Detailed in *The Woman Behind the New Deal: The Life of Francis Perkins*, by Kirstin Downey, Doubleday, 2009.

Getty Images

Francis Perkins, the first woman to serve in a President's cabinet, was the "moral conscience" of FDR's New Deal. The economy of the nation, she believed, was not dependent upon factories, farms, and trade, but upon people. The ravages of robber baron "capitalism" and crash of the banking system in the Great Depression, had pauperized large sections of the nation, thrown millions into penury, and created a class of "forgotten men." As the Secretary of Labor, Perkins worked with President Roosevelt for twelve years, to recreate the American System, based on the dignity and potential of all of the nation's citizens.

with an increasing amount of the financial system linked to the economy, rather than to banks. The physical improvements, which built up the industrial strength for the logistics-in-depth needed later to win World War II, would not have been possible without Roosevelt's return to the American tradition of the credit system.

Restore Glass-Steagall!

Before there can be a return to a national banking system, the purpose of which is the promotion of the high-technology vectored growth of the economy, and the well-being of the population, there must be a purge of gambling debts from federal responsibility.

Estimates are that the current magnitude of outstanding derivatives claims accumulated as a product of speculative financial practices, now measures in the hundreds of trillions of dollars, perhaps reaching even to quadrillions. Even when compared to the current nominal global Gross Domestic Product, estimated at around $70 trillion, it becomes immediately apparent that this debt can never be paid. The vast majority of these outstanding claims are of a purely speculative character, with absolutely no connection to legitimate, necessary, productive economic activity. To continue to bail out this vast bubble of gambling obligations on the back of a collapsed and rapidly shrinking real economy, would be to create, rapidly, Weimar-style hyperinflation on a global scale, and an economic crisis of Dark Age proportions.

Having nearly reached the limit of keeping up with debt obligations, even with $85 billion per month being poured by the Federal Reserve into this orgy of speculation, a new bank "bail-in" program, to steal the savings of depositors, is being implemented in depression-wracked Europe, and is in the wings here. Read carefully the provisions of the 2010 Wall Street Reform and Consumer Protection Act, or Dodd-Frank Act. The hard-earned savings of citizens are to be used to help "recapitalize" bankrupt banks.

Reinstituting FDR's Glass-Steagall policy would halt this catastrophe. By restoring the separation between commercial and investment banking, Glass-Steagall divides obligations into two separate categories: legitimate and illegitimate, the latter being far greater than the former. The government would have no responsibility to pay back losses accrued through speculative activity, thus transferring these trillions in liabilities from the government's books and people's livelihoods. The megabanks—JP Morgan Chase, Citigroup, Morgan Stanley, etc.—would be forced to split themselves in two parts: the so-called "investment arms" on the one side, and plain, old-fashioned commercial banking on the other. Under the Glass-Steagall law, only commercial banks receive federal guarantees; "investment houses" do not enjoy such protection. Although the trillions in outstanding "assets" might not be explicitly cancelled or eliminated by law, these debts would now be the responsibility of the financial institution, and not the American people, and without the protection of the federal purse, these assets will quickly dry up on their own. The nation would be freed from this cancer, and our commercial banking system restored to its necessary and indispensable function, which was the stated intention of Franklin Roosevelt's original 1933 Glass-Steagall Act.

Bear in mind that the actual effects of today's policies of liquidating the nation's people and its physical economy in order to maintain the financial "economy" are not accidental, they are intentional. As the Queen of England has so directly pointed out, continuing current financial policies, combined with energy policies based upon "green" technologies from the feudal Middle Ages, would require the reduction of the world's population to "appropriate" Middle-Ages levels; a reduction from nearly 7 billion, to less than one billion persons.

The state of the nation is clear: Detroit, the center of the World War II "arsenal of democracy," and key to the machine tool sector of our industrial society, is in bankruptcy, its buildings being demolished, and its skilled workforce, robbed of all social services and earned pension payments, is left in penury. Food production is declining catastrophically, as commodity speculation and "green" programs to substitute food crops for fuel are combined with "natural" crises, which could have been prevented decades ago, with the proper investment in water and other infrastructure. Hospitals, libraries, and cultural centers are closing their doors. Youth unemployment has skyrocketed by 50% in the past five years, and the future has been stolen from young people by a President who has worked tirelessly for four years to destroy the nation's space exploration program.

Since 2008, economist Lyndon LaRouche has led a national, and now international, fight to restore Glass-Steagall, recreate a national bank of the United States, and embark upon the great projects that define the future of the nation.

The lack of courage, and outright corruption, of our federally elected officials in Washington have required the mobilization of the citizenry of the country to force this return to American System economics. Now, time is of the essence. Every citizen must take responsibility for the future of the nation, which must be based, not upon "common sense," but upon what have been its true historical foundations.

This article draws upon the June 2013 Platform for a New Presidency *(third edition), published by the LaRouche Politcal Action Committee.*

One of President Roosevelt's first acts in office was to sign the legislation creating the Tennessee Valley Authority. Fundamental to the integrated resource management of the Valley's river system through construction of dams for power generation, flood control, and navigation, was the uplifting of the standard of living of the population. Here, a bookmobile brings the modern world to the Valley.

Tennessee Valley Authority

INTERVIEW: Bill Johnson

The Tennessee Valley Authority: A Key FDR Program Under Attack

On May 18, the Tennessee Valley Authority celebrated its 80th anniversary. The TVA was designed to develop the extremely poor southeastern region of the United States using the authority of the Federal government, but with the flexibility to choose the best path. Along with the package of measures, such as the reorganization of the banking system through the enactment of Glass-Steagall, and the regulation of critical infrastructure in laws such as the 1935 Public Utility Holding Company Act, the TVA has been a model of large-scale, integrated economic and resource development, for the rest of the country, and around the world.

Upon release of the Obama Administration's FY14 budget proposal on April 10, officials of the TVA, citizens of the Valley, and their elected Federal representatives learned that the Office of Management and Budget (OMB), under a chapter titled, "Creating a 21st Century Government," had included the following: "Given TVA's debt constraints and the impact to the federal deficit of its increasing capital expenditures, the administration intends to undertake a strategic review of options for addressing TVA's financial situation, including the possible divestiture of TVA, in part or as a whole." The budget document further notes that reducing or eliminating the Federal government's role in the TVA, which has achieved its objectives, could help put the country on a "sustainable" fiscal path.

The bipartisan and bicameral response from Capitol Hill was immediate, with many lawmakers assuring constituents that this proposal "isn't going anywhere." But it is astonishing that this proposal could even be made, to potentially wreck one of the most dramatically successful economic development projects of the New Deal, based on arguments that are patently untrue.

In January of this year, Bill Johnson became president and chief executive officer of the TVA. Before TVA, Johnson was chairman, president, and CEO of Progress Energy Inc., based in Raleigh, N.C., for five years, and has been a lawyer representing the utilities. He has served as vice chairman of the investor-owned utility industry's Edison Electric Institute, and was chair of the board of directors of the Nuclear Energy Institute.

21st Century Science & Technology *Managing Editor Marsha Freeman spoke with Johnson at the Washington, D.C., office of the TVA, on June 26.*

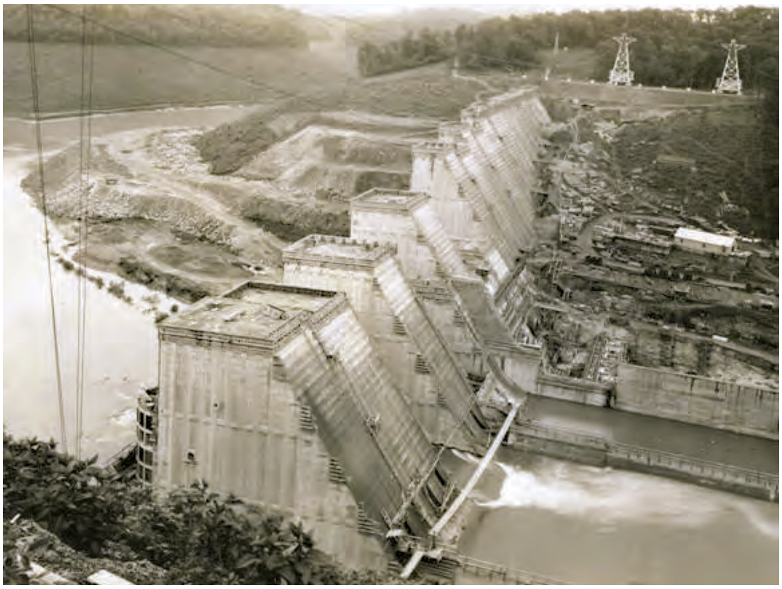
TVA

21st Century Science and Technology: Recently, two things of note have happened regarding the TVA. One was its 80th anniversary. Throughout its history, TVA has encountered opposition. It always seems that when people are making new proposals on how to change TVA, such as the recent one, they don't go back and read the old ones. And many of the arguments seem to repeat themselves. Now there is a proposal for a review to see if there is still a need for the TVA. Do you have any idea what that would mean?

Johnson: Not really. We've had several meetings with OMB about the proposal—introductory meetings, early, formative process meetings. What we hear is that the language means exactly what it says, which is that they think they need to do a review, to see if TVA still needs to be a part of the Federal government, and whether its mission has been completed. That is the extent of our knowledge.

Do you know when this strategic review will take place?

We are still in the formative discussion stage. What they've made very clear is that they want this to be collaborative, they want us to be part of this, which we like. We see it as an opportunity to demonstrate that the model is good and works. They also understand the need for speed, because to our workforce, this is a distraction. And distraction doesn't help you, either in safety, or performance. So I'm hoping it will be thorough and quick.



Five months after President Franklin Roosevelt signed the legislation creating the TVA, construction was underway on Norris Dam, named for the intrepid Republican Senator from Nebraska who led the fight for a national project to develop the Tennessee Valley.

One immediate effect of this disruption, which people on Capitol Hill have pointed out, is that the uncertainty itself can affect your credit rating and selling of bonds.

Our bond spread widened half a billion dollars on the announcement. You sell a bond, and you buy it, but there's a secondary trading market, which doesn't have to do with the price of the bond, but with how much you are willing to pay above or below the price. It's in basis points. The higher the basis point is above the benchmark, the less value you have in your bond. The spread went up 17 points, which is about half a billion dollars. So the bondholders lost a half billion dollars in value the day of the announcement. It's come back, but it's still at about $425 million. We have several billion dollars in refinancing to do this year. So our cost of money may change, just on this announcement. We have to wait and see. But we're on a fiscal year, so we have to be out there by the end of September.

Would such a divestiture apply just to the power assets of TVA?

It is not all clear. The document says to do a strategic review of all options, including partial or total divestiture, so it could mean everything.

One of the things that would be difficult in replacing TVA is that so many pieces of it are integrated. The whole idea is integrated resource management across state boundaries. If you break up that chain, you have all these cost centers that somebody else will have to deal with. Unless they have Federal authority, they will have to do things differently at the state boundaries.

The TVA's Debt

One rationale that has been used to promote this proposal is the idea that divesting some of TVA's assets could be used to reduce its debt, and that this would lower the Federal deficit. Would it do that?

To be clear: *We get no appropriations from the Federal government, and haven't, on the power side, since 1959*. We've actually made money for the government. In 1959, at our last power appropriation, we had gotten $1 billion, cumulatively. We've paid back $3.6 billion, so we are not leaning on the taxpayers. In fact, we're helping the taxpayers. So I don't think that's part of it.

Who knows what motivation there is in these things? If you think about the value proposition of TVA, if you are an elected official in the Valley, it's easy for you to be supportive of TVA, because you see the value every day. And if you have some institutional or historical memory, you know what has happened over the last 80 years, and the role of the TVA and the local power companies in improving the quality of life.

There is a theory that this is part of the government, and that the government shouldn't be in these businesses. Technically, we are in the budget. Every year, we submit all of our budgets and documents to the OMB and the Congressional Budget Office; so if you're in the budget, you're also included on the deficit side, you're on both sides of ledger. So we have $24.5 billion in debt, and that shows up in the Federal deficit.

On paper.

On paper. But *that is all debt that is raised in the public markets*, which the government does *not* stand by. So technically, we're part of the deficit, but legally, the government isn't responsible for those debts.

Has there been any political activity locally in opposition to this divestiture possibility?

One of the prohibitions we have is that we do not lobby or advocate, because we are part of the Federal government, so we are not doing any of that. But the local public power association, TVPPA, which is the group of the 155 local power companies, has come out with a resolution opposing this. The American Public Power Association has come out with a resolution; there have been union letters to the White House. There is strong, and mostly uncoordinated support. You go to public meetings, you see people on the street—I met a woman the other day at a TV station who is 24, and she said, "I want to tell you how much I support TVA. My grandparents lived in the coun-

During its first decade, the TVA brought electricity to the poverty-stricken Valley, along with flood control, the eradication of disease, libraries, and modern agricultural technology. By the late 1930s, the TVA was circulating about 13,000 books a month. Spraying against mosquitoes (above)stopped the spread of malaria, and half a million people were inoculated against smallpox.

try. And I want you to know that people like me really support TVA." The support at home is pretty strong. It would take Federal action to do something; they'll have to pass a bill.

Would it have to amend the law that created the TVA?

Yes. We already have some ability to sell assets. There's a process to do this. They usually have to be declared surplus assets. But we also have bond covenants that say if you sell any substantial portion, you immediately have to fund the outstanding bond indebtedness. There are a couple of other hurdles here that you'd have to work your way through.

The fight now to reinstate Glass-Steagall is a perfect example of what was necessary to create the TVA. There was tremendous opposition from the banks and the private utilities to the law that created the TVA in 1933. And how many lawsuits were there during the first few years of the TVA, to challenge the law?

It went all the way up to the Supreme Court twice, I think. Our goal is to make sure that there is a 160th anniversary of TVA!

'Our Own Economic Development Company'

You have had a lot of experience in the investor-owned utilities, and seen both sides—public power and private. What do you think the impact might be if some of TVA's electric-generating assets were sold?

Two impacts: One impact that we hope doesn't happen but could, is that prices could go up. For example, we have the luxury of not having to pay dividends to shareholders. Our dividend comes back to the customer in the form of a lower electric rate.

We have some advantages that would be hard for a shareholder organization to match. So I would think the price would be a real issue. How much would the rates be? I think it would be hard for someone to do it cheaper than we do it.

The other impact is the non-electric piece: river management, resource stewardship, campgrounds, boating. These are all things other people can do, but someone is going to have to get paid to do them. I just don't see how, as an economic proposition, this would be done any better than it is today.

Because TVA pays for all of the non-electric programs out of its electricity sales?

Exactly right. And every utility, every power provider, does economic development. Mostly on the investor-owned utilities side; you do it to increase your sales. It's good business. We do it for a different reason. We do it so we can bring jobs and vitality to the Valley. And we do it in a form and a fashion, and on a scale that nobody else does. We're like our own economic development company. I've not seen anybody else who would approach it like this, especially if you have to invest some of your shareholder dollars.

The statistics for economic development in the Valley are very impressive.

Between about 2007 and 2012, 200,000 jobs created; $24 billion in investment. If you look over a longer period, it's millions of jobs.

In mid-June, the Howard H. Baker Jr. Center for Public Policy at the University of Tennessee, Knoxville, released Policy Brief 2-13, "Should the Federal Government Sell TVA?" The data that is presented is quite dramatic.

One rationale for the Administration's strategic study is the claim that the TVA is in an untenable situation, because it has a Congressionally imposed debt cap of $30 billion, and it has almost reached that ceiling. The Baker study reports, however, that the $30 billion debt cap for TVA was set in 1979. If you adjust that figure for inflation, it would be about $100 billion! They also report that there are investor-owned utilities that have more debt than the TVA does.

One of the charges that is made by the private utilities is that the implicit—which they admit is not explicit—government backing for TVA's debt gives TVA an unfair advantage, making its credit rating higher, so its interest rates are lower. But in the 1930s, the electric utilities were regulated through legislation such as the Public Utility Holding Company Act, because providing electricity was viewed not as a luxury, but as a necessity. Regulation ensured that the utilities would operate on a sound financial basis, with a guaranteed rate of return, if they met the requirements of the law. If universal access to electricity is a public good, perhaps the government should think about what the credit ratings, and credit availability should be, and not leave that up to the financial markets.

The question is, what is in the best interest of the people who get the service? Is it to have the lowest interest rate and highest credit rating you can, because you're providing a public good? That seems to makes sense to me.

What really drives the credit rating is the TVA Board's authority to raise rates to cover costs. That's really the foundation of it. We actually have a really good self-regulating system. The TVA Board sets the rates to recover the costs. Customers see the impact of cost increases immediately in their rates. So our job is to keep rates low. That circle sort of works—we keep the rates low, and we do enjoy a low cost of capital because we have the authority to raise rates, but the Board doesn't want to raise rates. They want us to be more efficient, more effective. It is the essence of public power. You have a board appointed by the President, but you have a stakeholder group, the customers, and they're really influencing the Board.

Without the TVA, the nation would not have been prepared to fight World War II, stated the Federal Power Commission after the war. Cheap and abundant hydro power made the TVA region a major supplier of aluminum for airplanes, along with processed metals, timber, chemicals, ship boilers, gas masks, and explosives. For the war effort, TVA built 10 dams; Douglas Dam was built in a record-breaking 12 months and 17 days.

Is the TVA's Work 'Finished'?

Another charge that's been made, is that the work of the TVA is really finished, so why do we need it? On the occasion of the 30th anniversary of the TVA, President Kennedy gave a speech at Muscle Shoals, Ala., where he responded to that charge, stating: "The work of the TVA will never be done until the work of our country is done."

I don't think that we at TVA are the people who should judge whether the mission is done or not. I think two groups should decide this: the people who own TVA, the people of the United States, through their elected or appointed officials, and more importantly, the people who receive the value, the mission recipients, should have a big say in this. These are the people who pay the entire cost, every day, of TVA. They are not only the value recipients, they are the payors. I think an interesting exercise would be to find out from the people who live there, who are served in some way by TVA, what they think. And I think that you'll find that the mission is not finished.

Just speaking personally, I'd say that the mission might be finished when everybody has a good-paying job, there is full employment, low power rates, and a good environment. Then, you'd be getting close.

Cleaner Power

Another event this week was President Obama's speech saying he would set new, stricter, environmental regulations for power plants through the Environmental Protection Agency, since the Congress has not done it. TVA has a number of older, more inefficient coal-burning plants, which it plans to retire.

It's 2,700 MW, 18 units, that are definitely going. There's a discussion about what to do with the rest of them.

There are two possible pathways: to sink a lot of money into 40-year-old plants to have them meet new environmental regulations, or what TVA has done, deciding to complete some of its unfinished nuclear plants.

We have a vision to be a national leader in low-cost, cleaner energy by 2020. That's the path we're on. We're going to retire the old coal plants. The average age of our coal fleet is over 51 years. So I like to joke that I would like to close the ones that are older than me! We have added natural gas, and we are finishing the Watts Bar 2 nuclear plant. So you see a transition to a much cleaner portfolio. We have a big wind portfolio, by southern utility standards. So we are moving in that direction.

TVA's work "will never be done," stated President Kennedy at Muscle Shoals, on the 30th anniversary of the TVA. "Let us all resolve that we, too, in our time, 30 years later, will, ourselves, build a better nation for 'generations yet unborn.'"

One of the things that is helping us is that we've had a significant decrease in demand, and, therefore, a significant decrease in revenue; that [second] part doesn't help. But the decrease in demand allows you to do some things in a window of five to seven years. Instead of thinking about, "What do I need to build?" you're thinking about, "How do I rationalize what I have?" Finish that big nuclear plant; retire some coal. Our emissions will be way down. The fuel mix will change. We will keep enough coal. If you're a producer, one of the things you want to do, is compete the fuels. You want enough coal to arbitrage against the coal price. But over time, the energy mix will have changed considerably. It will be cleaner and more environmentally friendly.

Innovation: the Nuclear Program

In nuclear technology, TVA has played a very important role in research and development, with the flexibility to move in to new areas. The most recent is to be the first utility to build and test a small modular nuclear reactor.

In the enabling statute we have, one of the things we're charged with doing is innovation in energy technology. People don't generally know this, but we do quite a bit of innovation. One of the key ones at the moment is small modular reactors (SMR), which we think has the potential to be a great technology. It lowers the capital risk. You're paying a fifth or a sixth of what you would pay for a big plant. The technology is pretty straightforward. It's similar to the reactors that have been used in aircraft carriers and submarines for the last 50 years. We just turn it up and put it in the ground.

It's a little more complicated than that, but I think there are three things: First, the capital risk is so much smaller, that it's easier to digest. One of things utilities have trouble with, is you build a big plant, but you probably don't need the whole big plant in the beginning. If you put plants in operation in thousand-megawatt chunks, that's a lot of plant. You put it in at 200 megawatts, or 180, it's easier to deal with.

Second, you can "drive" these nuclear plants—you can load-follow with them [adjusting the power output as demand fluctuates—ed.]. As a submarine goes faster and slower, you can do that with these reactors. For the big reactors, you want to put them on at 100% and leave them on until they run out of fuel, because when you maneuver them, the system changes; there are miles and miles of pipes, and everything is affected. So turn it on, and run it.

Third is the export [potential]. We have new [nuclear] entrants—Qatar, the UAE, Vietnam. It would be a good thing for them to start with a 180- instead of a 1,200-megawatt plant. So for those reasons, this is a very promising technology.

And TVA is looking at siting the first Small Modular Reactor?

We are in a partnership with Babcock & Wilcox and we got cost-sharing funding from the DOE. The partnership is called mPower, and we have a site at Clinch River, very close to Oak Ridge National Laboratory, that we have laid out. We're doing meteorological work there and soil testing, so we are doing a little preparatory work to be able to do this by 2020, 2021, depending on how long it takes to get through the Nuclear Regulatory Commission [licensing] process. The NRC has never licensed one of these. So that will tell us a lot about not just the commercial, but also the technical viability.

Babcock & Wilcox

Conceptual drawing of an underground containment structure housing two Babcock & Wilcox mPower reactor modules. On the right is a single mPower reactor, showing the scale of the structure.

As nuclear energy takes off, many developing countries will want the smaller reactors. Do you think manufacturing facilities will be set up in the TVA region to produce these small reactors?

B&W builds the military reactors for submarines and aircraft carriers. The idea here is that you build this plant in a factory; it will fit on a rail car and you take it to the site. They have some capability, but not to do a lot of these. The military doesn't get that many over time, so you have to expand the capability. And we have all those great transportation routes and a skilled workforce. I would love to see that happen.

I read that work at the Bellefonte nuclear plant, which is being completed, is being slowed down, and people are being let go. What is the reason?

The demand picture, mostly. We used to project growth for ten years at 2 or 3% per year. We're now projecting 0.4%.

Bellefonte was approved to be completed two years ago, but the TVA Board also wanted a brand new estimate [of the cost of completion] given the history of the Watts Bar estimate.[1] We have been working on engineering and asset preservation, but in that two-year period, demand has gone down considerably, and we lost USEC, which was our biggest customer, a 1,000-MW customer. So the need for the plant has pushed back. We haven't changed the date or made a different decision, but we have figured out that we don't need it when we thought we would need it. And we have some short-term needs that we really need to focus on. We need to finish Watts Bar II by the fourth quarter of 2015, at $4-4.5 billion. It's not so much the money as organizational capability and managerial mind-share.

One of the things you think about in a big organization is, what is our capability to be doing two [nuclear reactor construction projects] at once? You see Southern Company with two Vogtle units side by side on an existing site. Everyone would agree, I think, that the Southern Company is one of the better companies in the business, and they're having some trouble. I don't think we need to be building two units at the same time. Let's finish this one. Let's look at the fundamentals of demand and usage and see when we need that plant.

1. In 1985, TVA's Watts Bar Unit 2 nuclear power plant stopped construction, when it was 70% complete. In 2007, the TVA Board decided to complete the plant, with an initial projected 2012 start-up date. Cost and schedule overruns led TVA to revise the schedule in 2011, with a projected current start-up date at the end of 2015, and a cost that is more than double the original, 2007 estimate of $2.5 billion.

For an extensive history of the TVA, see "Roosevelt's TVA: The Development Program that Transformed a Region and Inspired the World," in the Summer 2011 issue of *21st Century Science & Technology.*

Economic Forecasting

The deregulation of the electric utility industry since the mid-1990s introduced a factor of instability to the entire nationwide industry. Utility long-term planning was made more difficult without government oversight. That is now combined with the current contraction of the economy, making forecasting what electric demand will be during the years it takes to build additional capacity even more difficult.

From World War II until 2007, we had growth. We averaged, sometimes, 3 or 4% [per year]. But then we dipped. We're in the fifth year of a decline in demand. As we now project our peak [demand], we will be back [up to the 2007 level] in 2023. So this is a fundamental change in the dynamics. What if you guess wrong, and demand comes back by 2018? What if it doesn't come back until 2030? It's sort of a conundrum. I think this is a time to husband your capital, preserve your options, and have enough flexibility, so if you're wrong in any direction, you can do something about it.

Our view is that what we need is a new economic policy. Your region may be a little less affected, because, due to TVA, you can be pro-active in attracting and keeping jobs; but if you look at Detroit and the industrial heartland, they are in bankruptcy. The government historically has had the responsibility to create the conditions for economic growth, which is what TVA was mandated to do. And that needs to be applied nationally.

I think you're on the right track here. Let us think about economic policy that encompasses industrial policy, energy policy. All of these things go together. That's the TVA model, a whole integrated plan for the region. You can't talk about energy policy in a vacuum—it's helpful to know what you're trying to achieve through that policy, not just have a policy.

One of the things that is so striking about the TVA, is how it became a model for development in other parts of the world, such as the Three Gorges Dam in China. Is there still interest from other countries in the TVA model of development?

We recently had some Japanese visitors, and I think we have some coming from Vietnam, so, yes, there's still a great deal of interest. The Chinese have come within the last six months. What they're interested in is integrated resource-management planning. How do you make all these things fit together? My own experience is that TVA is known much more thoroughly internationally than it is nationally. It's kind of amazing.

We are also a good example of thinking about the lessons of Fukushima, because our nuclear plants are all downstream of major dams. So the flooding aspect is something for which we are a good model for the rest of the industry. There's probably not going to be a tsunami, but there are 49 dams on that [Tennessee] river, and there's a lot of water impounded on that river, so if you have a dam failure or two, then you have a flooding issue, and you have to be able to make sure you're cooling that [nuclear plant] core.

Had the TVA thought about that possibility before the Fukushima accident?

This is interesting. These plants were licensed as wet plants. In other words, licensed to be able to be flooded [and maintain safety]. But the projection of what a probable maximum flood is has changed, so we're having to do some work to move safety systems to higher elevations. They were built to be flooded, but the flood might be a little bigger, so we're moving things up.

Are other nuclear plants built that way?

There are a number of them around the country. The one in Nebraska, Fort Calhoun, which had big flooding, was licensed as a wet plant. A number of them are on hydro rivers.

Does that mean that the plant automatically shuts down, or does it keep operating?

If you have a flood of that proportion, you won't need the electricity, so you shut the plant down. In any kind of major flood, you would shut the plant down, but you would move clean water over the fuel and through the steam generators. You protect the asset, preserve the asset, but you wouldn't be generating power.

A recent news article reported that in your region, there was 60-year rainfall, and TVA flooded certain non-essential areas such as golf courses to cope with the water, but people's homes were not affected. The estimate was that $800 million in damages was averted.

That was in January. If you look over the history, the number is some significant billions of dollars. Sometime when you come to Knoxville, you should see the River Operations Center. We had, during those rains, several of the dams dealing with record amounts of water. Think about that—80-, 90-, 100-year-old dams, with record amounts of water. The ability with which they can move that water with precision is unbelievable.

The people there say, "We've got to move this water. It's going to flood here, but it will be 100 feet from any structure." And they can do that with precision. It's so many millions of cubic feet they're spilling per second. If you go back in history and look at the flooding, and the ravaging nature of that, controlling that river has been one of the TVA's major accomplishments.

The other thing that impressed me was that because of the connections, this management of the Tennessee River also helps to manage the Ohio and Mississippi rivers.

The Tennessee River forms in Knoxville from the French Broad, the Little, and the Holston rivers. It goes down, doesn't touch Georgia—Georgia wants some of this water—Alabama, Mississippi, back up east of Memphis, all the way to Paducah, Kentucky, and runs in to the Ohio River. The Ohio runs in to the Mississippi, and that goes to Memphis. So the coordination with all those rivers, and the Army Corps, is all pretty important.

How do you interface with the Army Corps of Engineers? If the decision were made to break up the TVA, would the Army Corps have to pick up operation of the dams?

They would certainly be a likely candidate, but you'd find private enterprise to do that, too; private river-management companies. We interface very closely with the Corps because we control the river, we control the shoreline, so any appurtenances you'd want to build, boat docks, we control all of that. The Corps controls navigation. So we provide the water for navigation but they control the navigation, and they run the locks. There are a lot of locks.

You know, when TVA was formed in 1933, you could not travel the length of the Tennessee River. You would get down to the shoals, which is a big, muddy flat spot. Today, there are a lot of locks, and we are in communication in real time with the Corps. How much water do you need in the Mississippi? How much do you want in Huntsville? That's a pretty daily occurrence. [Today, the Tennessee River] is a very heavily used transportation conduit, maybe the most heavily transported river, or second behind the Mississippi. The savings from using river transportation, versus other forms, is hundreds of millions [of dollars] every year, which also helps with economic development.

In the 1960s, at the same time that President Kennedy was at Muscle Shoals to celebrate the 30th anniversary of the TVA, there was a program put forward, and developed by the Ralph M. Parsons Company, called the North American Water and Power Alliance, or NAWAPA, which would have built on the TVA model, and moved it west. The Great American Desert, with such rich soil, but a serious lack of water, could have become a breadbasket for the country. But this was never built. We have resurrected and improved and expanded the NAWAPA program, as a great infrastructure project that must be built. The success of the TVA is an important precedent for taking on such a large-scale infrastructure project.

Thank you for taking the time to discuss the past and future of TVA.

It's been a pleasure.

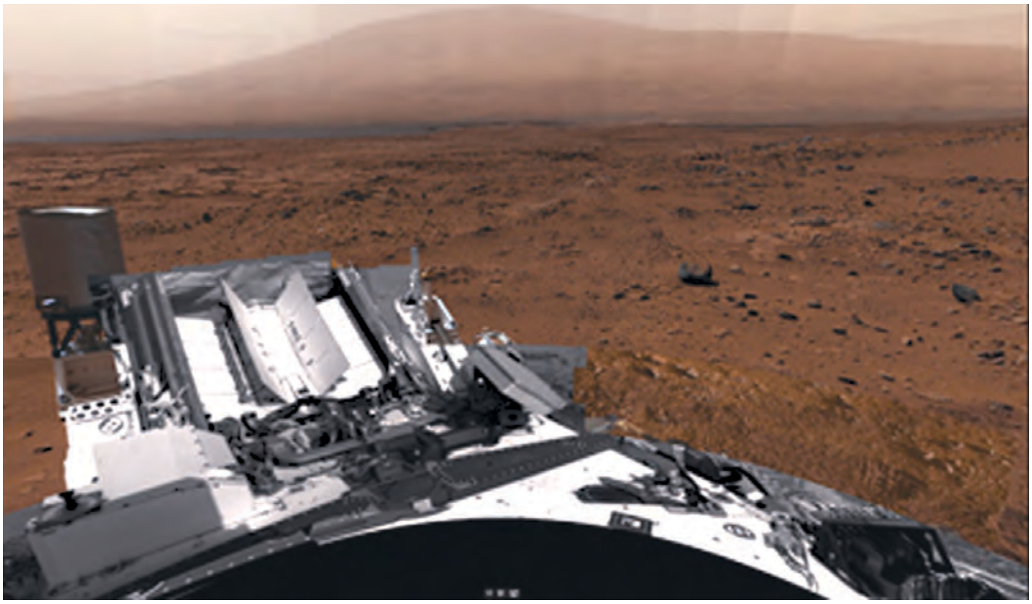
SPACE

Curiosity Opens Many Windows To the Solar System

by Marsha Freeman

As we mark the one-year anniversary of the successful landing of NASA's Curiosity rover on Aug. 6, planetary scientists are reaping the early results of a set of scientific experiments never before carried out on Mars. The highly sophisticated, nuclear-powered rover will help both uncover the evolutionary history of the planet, and describe in detail where it is in that process today. But the success of the mission is not only important based on what the Curiosity will find, but the precedent it sets for the missions of the future exploration of Mars.

The question of whether there was, or is, life on Mars has been the prime motivation for the series of missions in NASA's Mars exploration program. The question of whether life presents itself uniquely on Earth, or is a universal characteristic of all of Creation, has occupied the greatest minds in science for generations. While Curiosity is not expected or designed to provide a definitive answer to that question, it will extend and enrich our understanding of crucial aspects of the pathway of development of the planet, through its geological, chemical, and hydrologic history, and provide more insight into whether that pathway has included life.



This full-circle view, which includes the Curiosity rover and distant Mount Sharp, toward which it is headed, was created by combining nearly 900 images, taken by the rover between Oct. 5 and Nov. 16, 2012.

But Curiosity also has "a higher calling." Strategically located between our planet and the main belt of asteroids, the rover, complemented by a set of spacecraft in orbit around Mars, has a bird's-eye view of stray debris left over from the creation of the Solar System, some of which has, and will, threaten our planet. Curiosity can be thought of as a pathfinder for what must be a series of sentinels, helping to keep watch over the safety of the Earth. In this regard, telescopes and other scientific infrastructure located on or near Mars provide a new perspective on the activities in our celestial neighborhood.

The technological breakthroughs required for the next steps in exploring Mars, including most emphatically, the deployment of fusion energy, will also create the ability to interfere with any potential extraterrestrial threats to Earth. From this unique vantage point, in the future, we will be able to not only find and, when needed, disable individual asteroids and comets, but discover the generating principles that created these seemingly wayward objects, and the Solar System, itself.

From the orbit of Mars, we will be able to gain new insight into the development of the Solar System, as well as a new perspective of the Earth. This is not because we will be able to "see" the Earth from Mars, but because we will discover new generating principles in the creation of life and the galactic processes within which they occur.

The End of 'Curiosity'?

The truly astounding event, however, over this past year, has not been the performance of Curiosity, but the intention to have this magnificent scientific laboratory be the last one of its kind. The Mars exploration program has been savagely attacked by the Obama Administration, as future missions have been cancelled, delayed, and de-scoped.

Since the mid-1970s, when the Viking landers and orbiters revealed a planet that had a geologically dynamic past, and a history of flowing water, various missions had been proposed, and some were even approved, to bring to bear on Mars the kind of infrastructure deployed on our planet and in near-Earth space, to gain a detailed understanding of what once may have been a more Earth-like world.

Proposals were considered for Mars airplanes, for in situ study of the atmosphere; weather stations to help guide safe landings on the surface; networks of seismic stations to determine the interior structure and composition of the planet's core; fleets of communications satellites in Mars orbit, for uninterrupted exchanges with Earth; an interplanetary Internet, to manage and transfer huge amounts of data; robotic systems on the planet's surface that could be operated remotely from Earth, or one of Mars's moons; and telescopes with an array of scientific instruments for a new age in the exploration of space. Using the indefensible excuse that there is not enough money for space exploration, the Obama Administration has put Mars on the chopping block.

We must decide now if we plan to have a future as a nation, as a civilization, as life on Earth. The threats are immediate, in terms of the current worldwide descent into barbarism through an existential economic collapse; unknowable, in terms of the threat to Earth from space; and long-term, since, at some point in the distant future, we know that our Sun will no longer provide us with the means for life on Earth.

While it is not the case that a space exploration program meets these challenges in itself, there will not be a resolution to any of them without one.

Mars: A Habitable Planet

In March, scientists announced a major step forward toward answering the question of whether Mars could possibly have supported life. Curiosity's instruments revealed the groundbreaking results.

Although numerous previous orbital missions, and the still-operating Opportunity rover, have confirmed that there once was flowing water on Mars, the chemical composition of the minerals that Opportunity examined indicated that past water in Meridiani Planum was acidic and salty, not conducive to supporting life. However, data gathered from orbiting satellites had indicated the presence of clay minerals in Curiosity's region of Mars, which held the possibility for a different chemistry.

Curiosity found that the composition of the clay, examined from a drilled sample inside a rock named "John Klein," afer the mission's deputy project manager, who died in 2011, indicated that it formed in water that was neutral, or mildly alkaline.

If you were on the planet, you would have been able to drink it, was the way Curiosity chief scientist John Grotziner described it during a March 12 press briefing.

Second, a detailed analysis of the chemicals in the rock sample identified sulfur, nitrogen, hydrogen, oxygen, phosphorus, and carbon—all key ingredients for life. Combinations of pairs of some of the chemicals could provide the energy source for microorganisms, the scientists reported.

Last month, scientists released findings from the Sample Analysis at Mars (SAM) suite of instruments, which measures the abundance of different isotopes of elements in the atmosphere. How, why, and how quickly the atmosphere of Mars has escaped into space will help reveal aspects of the geologic, chemical, hydrological, and potentially, biological history of the planet. A thicker atmosphere, which would indicate a warmer climate, would have allowed liquid water to exist on the surface of Mars.

Curiosity scientists reported that as heavier isotopes would tend to remain near the ground, or, for a longer period of time, in the atmosphere, as lighter isotopes more easily escape, determining the ratio between them sheds light on Mar's atmospheric history. The enrichment of heavier isotopes as measured by the instruments verifies the expected process of evolution of the atmosphere.

Curiosity has spent a highly productive half (Earth) year exploring an area within 500-yards of its initial landing site. On July 4, the mobile laboratory began the five-mile trek to its ultimate goal—the three-mile-high layered mountain in the center of Gale Crater, in which the rover landed one year ago. The drive to Mount Sharp will be done slowly and deliberately, and will take more than the rest of this year to accomplish. The mound in the center of the crater was formed as a result of an impact on the surface of the planet, likely more than 3 billion years ago.

Over time, a sequence of deposits was laid down, most likely through the action of flowing water, forming sedimentary layers. Each layer of the stratified structure encases a different period in the geological and chemical history of Mars.

This is similar to the way the geological history of Earth can be read through the stratified layers of formations such as found in the Grand Canyon. Scientists hope to read this history in order to map the evolutionary changes in the planet, over billions of years.

Vernadsky on the Cosmic Origins of Life

In tackling the question of the origin of life on Earth, the great 20th-Century Russian-Ukrainian scientist Vladimir Vernadsky proposed that the Earth's continual interaction and exchanges with the rest of the cosmos had to be taken into account, in considering the appearance of life. If this is so, he posited, there is every possibility that there is life elsewhere in the cosmos.

In creating the science of biogeochemistry, Vernadsky explained that although there are geological and chemical prerequisites required for life, it was life's creation of the biosphere that evolved Earth's geology and chemistry. Vernadsky made these discoveries through the study of basic processes of the planet, and his ability to conceive of a higher-order process. He was the first to initiate an intensive study of the chemical and atomic—that is, isotopic—properties of life, examining the distinguishing earmarks of life in the Earth's biosphere, we well as a similar examination of meteorites.

Finding life on Mars, therefore, is not simply a question of looking intensively for microbes, or their remains, but applying Vernadsky's concepts and methods to discover the underlying principles of how life developed on Earth and may have developed on Mars.

Curiosity is the first step in this investigation, as it advances the detailed examination of the geochemical history and the current state of Mars. In the future, advancements will be made by applying Vernadsky's most critical breakthrough—the deployment of man's unique creative thought, to planetary exploration. New platforms of technology that are man's tools, and the passion and commitment to create a future for humanity, will lead to the answers to some of mankind's most profound questions.

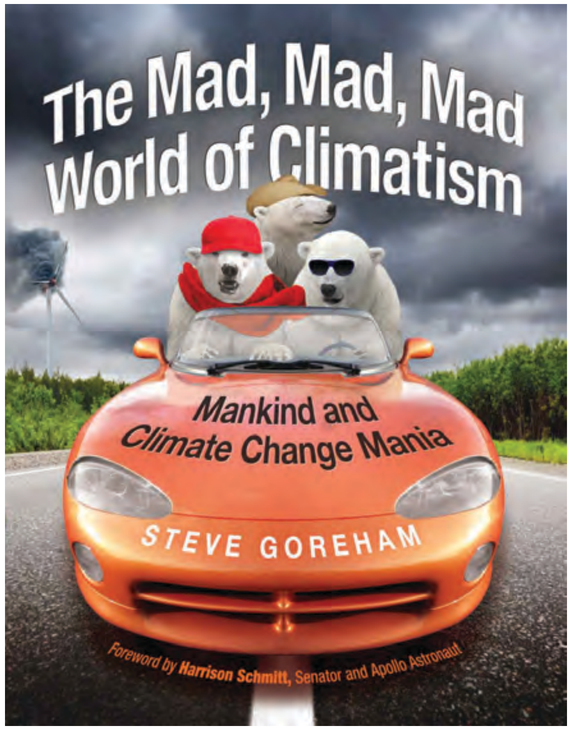
A Convenient Truth

by Jason Ross

The Mad, Mad, Mad World of Climatism
Steve Goreham
New Lenox, IL: New Lenox Books, 2013
Paperback, 312 pp., $22.95

Many books, videos,[1] and websites do an adequate job of dismantling the fraudulent notion that the human species, by its industrial release of CO_2, is causing massive, irreversible damage to the planet's climate system, but Steve Goreham's excellent book is one of the few that will make you laugh along the way!

As *21st Century Science and Technology* has covered for years,[2] anthropogenic global warming (AGW) is the latest in a series of environmentalist tactics with the direct goal of preventing human progress and ultimately, reducing the world's population. This is not a result of a primary goal of improving or "saving" nature, but is the direct goal of an oligarchical world outlook, as expressed by the empires of the past, and the British Empire of today. It is significant that, in addition to tackling the flaws in the AGW hypothesis, Goreham addresses the catastrophic effects on human life that would come about from attempts to reduce carbon dioxide emissions. Obama's recent condescending remarks to the youth of South Africa, that "the planet will boil over" if Africans raise living standards "to the point where everybody has got a car and everybody has got air conditioning, and everybody has got a big house" are a case in point.



Between doctored temperature readings, falsified extrapolations, peer-reviewed control of publications, and government funding allocations, *The Mad, Mad, Mad World of Climatism* covers all the scientific bases, and many of the political ones as well. Some activists cite the "precautionary principle," urging us to ask "well, what if global warming is real?" But this agnostic outlook cuts the other way as well: the cost to society of adopting a "carbon neutral" economy is no mystery, and it is immense. Far from a purely scientific debate, climatism as a religion demands huge sacrifices for what is expressed as a fundamentally ideological desire that mankind have no impact on "nature," even though such an approach is unnatural to our species.

Not to spoil the book, I'd like to quote a few among Goreham's amusing side-notes, set apart from the text in colorful margin boxes. One is a 1977 quote from Amory Lovins: "If you ask me, it'd be little short of disastrous for us to discover a source of clean, cheap, abundant energy because of what we would do with it." A similar anti-humanity quote from Paul Ehrlich reads: "Giving society cheap, abundant energy would be the equivalent of giving an idiot child a machine gun." We also read about an Australian law that pays a bounty for shooting feral camels from helicopters, in order that the 45kg of methane flatulence they emit yearly be abated! On the attempts to get raw temperature readings from the now-infamous and discredited Climate Research Unit, director Phil Jones wrote: "...We have 25 or so years invested in the work. Why should I make the data available to you, when your aim is to try to find something wrong with it..."

I hope that you will treat yourself to reading this excellent book on the fraud of climatism, told from the humorous (while rigorous) standpoint the subject deserves!

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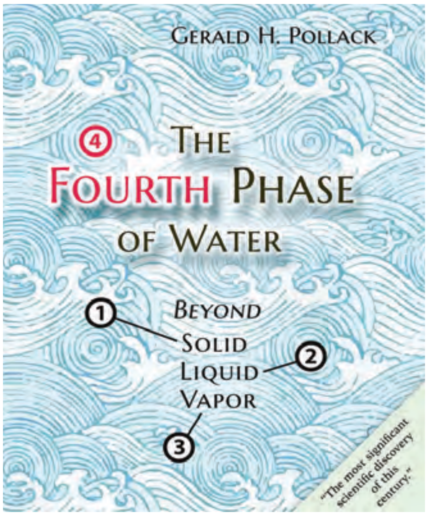
1. Such as the 2007 film, *The Great Global Warming Swindle.*

2. See "Where the Global Warming Hoax Was Born," Marjorie Mazel Hecht, Fall 2007.
"The Sun, Not Man, Still Rules Our Climate," Zbigniew Jawaroski, Spring 2009.
"Yes the Ocean Has Warmed; No, It's Not Global Warming," Robert Stevenson, Summer 2000.
"There's No Global Warming, Because There's No Global Climate," Fall 2005.
"There No Coorelation Between CO_2 and Climate Change," Winter 2007-2008.
"Global Warming: More Hot Air," Howard Hayden, Spring 2004.

The Secret World of Water

by Liona Fan-Chiang

The Fourth Phase of Water
Gerald H. Pollack
Ebner and Sons Publishers 2013
$29.95



Water is not something that most people spend much time thinking about, and due to the nature of science today—to specialize, molecularize, and concentrate on minute details–most people assume that there is not much that a layman can wonder about water that hasn't already been explained. In his new book, *The Fourth Phase of Water,* Dr. Pollack challenges this notion, pointing out both that since water is all around us, we tend not to see it as phenomenal, and that since the focus throughout the twentieth century has shifted from looking for fundamental laws, to detailing consequences of assumedly known laws, basics can go long unchallenged. "If currently accepted orthodox principles of science cannot readily explain everyday observations, then I am prepared to declare that the emperor has no clothes," Pollack declares in his Preface.

The Fourth Phase of Water is the latest in a series of books on the subject, including *Cells, Gells and the Engines of Life* (2001), *Water and the Cell* (2006), and *Phase Transitions in Cell Biology* (2008), in which Pollack and his collaborators reveal the results of their many years of research on the unique, and previously unexplained, properties of water. This book's composition is paradox driven, meaning that there are no attempts to explain something unless the reader is first presented with something unexplained. In that sense, although the book may look and feel like a textbook, it is not composed as one, keeping the reader's mind hypothesizing and engaged. For example, chapter 1, titled "Surrounded by Mysteries," begins by listing fifteen everyday observations, such as gelatin desserts composed of 95% water but not leaking and warmer water freezing faster than cold water, and asks you to try to explain them. He follows this with an overview of the history which has led to current understanding of the subject, so that by chapter 3, the reader is ready to begin where the author did.

Water is ubiquitous, and yet a new field of study. For that reason, this book is recommended for everyone. The layman will appreciate that Pollack stops to explain technical phrases, while not slowing or dumbing it down. You will find that everyday activities can be experiments, and that you too can contribute valuable hypotheses. Scientists in other fields may find that the experiments and results presented give a new approach to their current studies.

How many fields can benefit from both the non-reductionist approach taken by Pollack and his team, and from the results relating to water and to life? Pollack points out, for example, that one of the biggest factors left out of every theory of water is energy, mostly radiant energy. Experiments performed in Pollack's lab and others showed that a layer of water along hydrophilic surfaces exhibits dramatically different characteristics compared to "bulk" water. They showed that this layer likely has a structure that is closer to ice than that commonly associated with liquid water, and that this layer, named the "exclusion zone" by Pollack, grows in extent with incident light. In addition, far from being neutral, a characteristic commonly attributed to water, the exclusion zone is negatively charged, and its build-up creates a complimentary positively charged area just beyond it, thereby storing that incident energy in both new bonds and in electric potential.

If light can provide the energy required to build up this crystalline liquid, then what about most of the waters of the Earth, which are subjected daily to incident solar radiation? In chapter 7, Pollack points to a few cases, including that of experiments performed by Giorgio Piccardi who found that chemical reaction rates varied with periodicities of solar activity. Several processes on earth have now been shown to have possible coincidence with longer term cosmic cycles, such as the onset of the "seasonal" flu, variation in frequency of earthquakes and volcanic events (60 million yrs), sea surface temperature (140 million years), biodiversity cycles (60 and 140 million years), etc.[1] What role might water possibly play in mediating these interactions?

Much more work needs to be done. After reading this book, you will look forward to further publications which, as Pollack mentions in the forward, will include the subjects he couldn't fit in this volume.

1. See Planetary Defense: An Extraterrestrial Imperative, at larouchepac.com/planetarydefense

Scientists are People, Too!

by Marsha Freeman

Fun in Fusion Research
John Sheffield
Waltham, MA: Elsevier, 2013
Hardcover, 145pp., $69.95

Fusion energy research is serious business. Generally, it is a life-long commitment, involving long hours and weekends, along with optimism and dogged determination. Recently, fusion research has been increasingly in the news, as construction moves forward on the International Tokamak Experimental Reactor (ITER) in France, which is being designed and built by nations which together encompass most of the world's population. As an inexhaustible source of power, using seawater-derived fuel which is universally available, fusion energy is recognized as an urgent requirement for the future.

John Sheffield, who has been involved in fusion energy research for more than 50 years, has seen it all, including the foibles, missteps, failed experiments, and mistranslations that a global scientific research effort create. He has participated in and made contributions to both the theoretical and experimental aspects of plasma science and fusion research. But most important (for this book), he has clearly had a keen eye, and an acute memory, for the very human and "fun" side of such serious work.

There is enough detail explaining fusion, and describing the history and variety of experiments over the last half century, to inform the new reader. But the enjoyment of Sheffield's book is immediately obvious from the cover photograph. Here, we have a fusion tokamak-shaped cake, created to celebrate the Department of Energy's approval of a fusion experiment at the University of Texas. The 24 sponge cakes, covered in burnt-orange frosting, represent the torus containing the fusion plasma, which is surrounded by a cardboard set of toroidal magnets. What happened to this artistic creation in the hot Sun, is one of the entertaining tales of this book.

After more than 50 years of research in fusion, Dr. Sheffield remains optimistic that although there are still challenges ahead, he states, "I remain convinced that fusion energy will be realized for the benefit of the world."

A Gem of Scientific Pedagogy

A Review of the Deutsches Museum

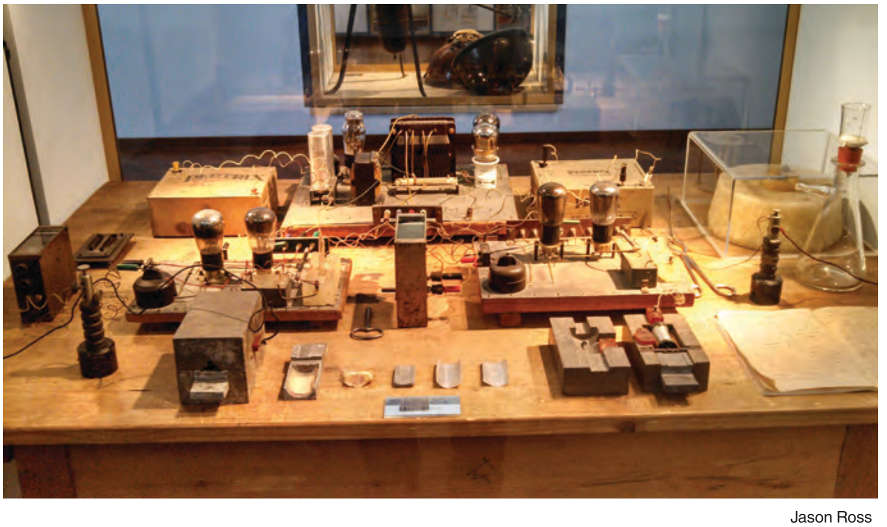
by Jason Ross

On a recent trip to Europe, I had the good fortune to be able to visit the Deutsches Museum in Munich, an extraordinary institution that would have deserved a week-long visit to do it justice. This amazing facility was founded in 1903 by the work of the electrical engineer Oskar von Miller, who pioneered the use of high voltage transmission lines, and three-phase power. Fully opened in its current location in 1925, the Museum currently houses exhibits on all branches of science and every conceivable field of application of technology—the applied arts that make modern economy possible.

Simply walking through the exhibits on such technical arts as ceramics, hydraulic engineering, metallurgy, paper manufacture, and tunnel construction gives an immediate sense of the depth of discoveries and centuries of experience represented in our current capabilities. They also make many visitors cognizant of just how unaware they are of how the manufactured objects that surround them every day are produced. Exhibits of tools, both scientific and cultural, from machining implements to measurement apparatus, from computer components to musical instruments, demonstrate the wealth of creations formed by human minds over our history.

Jason Ross

Most astounding to me, however, (at least on my short visit!) were the exhibits on the history of science. Completely unlike a textbook, which, made of paper and ink, can at best describe experiments, and, more often than not, simply gives the resulting formulas as a basis for answering problem sets, the Deutsches Museum brings the discovery process to life. The enormous physics section encompassed every imaginable aspect of mechanics, and used demonstrations (usually interactive) to make clear the phenomena that provoked the development of the theories used to explain them. Torsion, friction, angular momentum, speeds of bodies in free-fall, levers, wedges, pulleys, Bernoulli forces, gyroscopes, fluid flow, and much more, would serve as an ideal educational excursion for elementary and middle-school students. More challenging experiments in electrostatics, magnetism, and electrodynamics trace the way to the development of the motor, cathode-ray tube, and transistor, and reify concepts that, of necessity, can only be abstract when read in books. All children should have the opportunity to experience first-hand such experimental demonstrations, the global patrimony of human thought.



Jason Ross

One of the more astonishing displays at the Museum.

The only acceptable goal for an educational system is one that prompts students to reproduce breakthroughs of the past by confronting them with the experimental evidence written in nature's book itself. On this basis, our young future biologists, fusion scientists, and rocket engineers will develop a firm internal foundation for knowledge, based on no authority other than the world itself, and a familiarity that will inspire confidence in acting on that surrounding world to control and improve it!

The Deutsches Museum provides an inspring conspectus of what it is to be human.

SPECIAL REPORT SAMPLE

The following is a preview of our Special Report, entitled: "Nuclear NAWAPA XXI: Gateway to the Fusion Economy." The full report is available on our website.

A Call for an International Crash Program

Creating the Fusion Economy

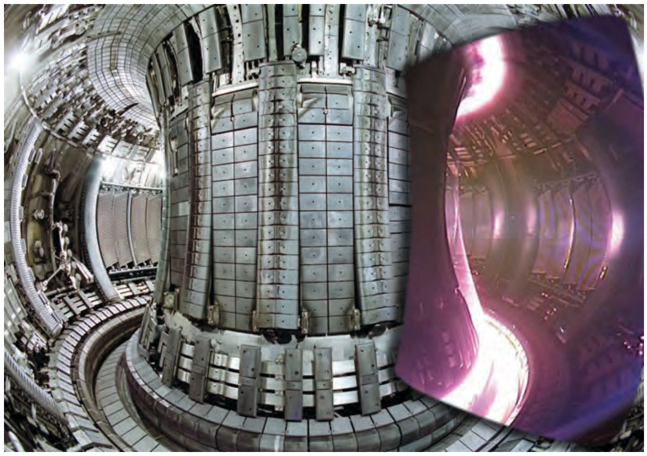
We have reached the point that not only is man's power to harness the processes of the Sun an emerging reality, it is in fact an existential necessity.

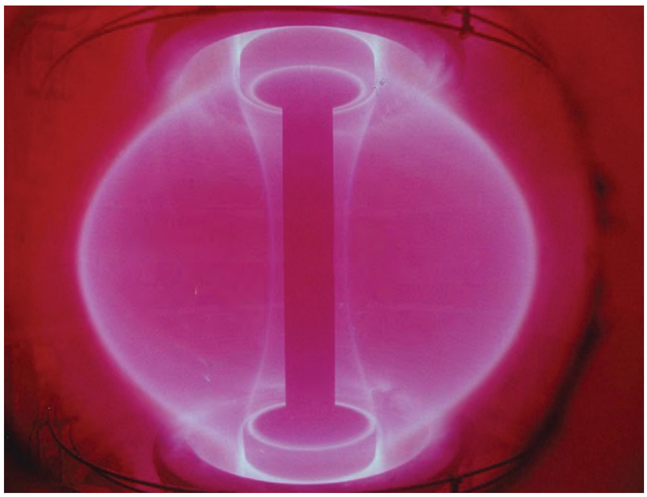
We must now direct our creative faculties and physical resources, in an international collaboration reaching from Eurasia to the Americas, towards achieving critical breakthroughs in the domain of thermonuclear processes. This is the already-delayed next step in the willful process of human evolution, illustrated by the previous successive transitions from a wood-based society, to a coal economy, then to petroleum and natural gas, followed by the higher potentials of nuclear fission power (see Appendix 1: Energy Flux Density).

By increasing what the American economist Lyndon LaRouche has defined as the *energy flux density* of the economy, we gain control over processes of higher energy throughput per unit of area, as expressed in a wide range of technologies, infrastructure projects, and production methods. With the fusion economy energy supplies become relatively limitless, since the fusion fuel contained in one liter of seawater provides as much energy as 300 liters of petroleum.

But this is more than limitless power. The fusion economy brings mankind into the domain of "high energy density physics," dealing with thermonuclear reactions and plasmas with energy densities on the order of 10^{11} joules per cm^3—a billion times the energy density of the battery in your smart phone—and the dynamic interrelationship between plasmas, lasers, fusion, and antimatter reactions. For example, ultra-high powered, petawatt, lasers are capable of producing extremely brief pulses of laser light 1,000 times as powerful as the energy coursing through the entire U.S. electrical grid (see Appendix 2: "The High Energy-Density Physics Platform").

This new platform brings a wide range of fusion-related technologies and experimental capabilities, from high-powered lasers, to particle accelerators, to high-temperature plasma generators, to directed energy explosions, all working in a dynamic relationship, complementing each other to transform mankind's entire economic system, eliminating any concerns over limited power or limited resources. Given the crises both in the United States and globally, this is an absolute necessity, and requires a global crash program, comparable to the Manhattan Project or the Apollo Program, but on an international scale.





Top: EFDA-JET; Bottom: U.K. Atomic Energy Authority:

Above, the Joint European Torus, below, superheated plasma.

Full transformation will take some time, but certain fusion technologies can provide economic benefits in the relatively short term.

Already at the beginning of the fusion age, such visionaries as the co-founder of Lawrence Livermore National Laboratory and leading proponent of the Strategic Defense Initiative (SDI), Dr. Edward Teller, supported the utilization of the immense energy density made available with fusion reactions, in the form of Peaceful Nuclear Explosions (PNEs). It was demonstrated that this could revolutionize canal building, port construction, mining, aquifer creation, tunneling and other requirements of bulk

What is Fusion?

As opposed to fission, the breaking apart of the heavier elements (uranium, plutonium, thorium, etc.), thermonuclear fusion is the bringing together of the lightest elements (hydrogen or helium isotopes for example). When two isotopes of hydrogen are fused, the process produces helium and a free neutron (together weighing less than the sum of the two original hydrogen isotopes) plus the release of energy in accordance with Einstein's famous discovery that small amounts of mass can be converted into large amounts of energy (in proportion to the speed of light squared, $E = mc^2$).

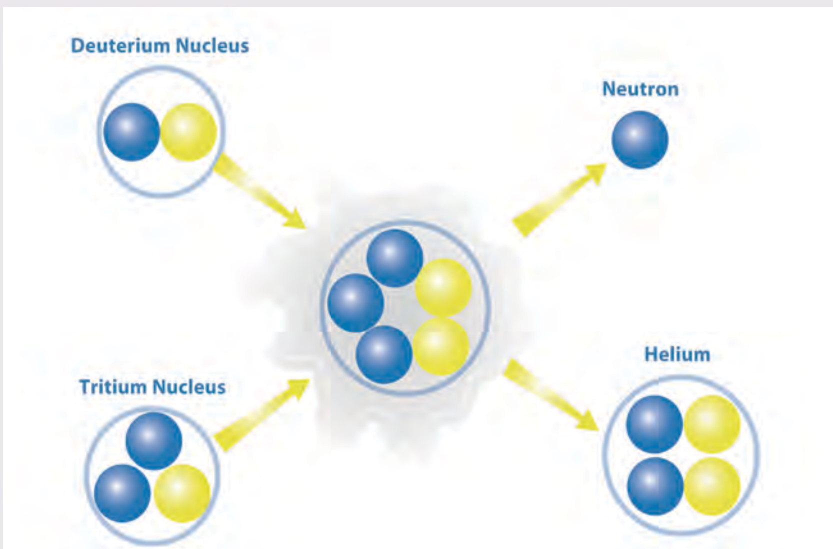
These fusion reactants have energy densities millions of times greater than coal, oil, or natural gas, resulting in orders of magnitude less fuel required to generate comparable amounts of energy. For example, the same amount of electricity can be generated from either two million tonnes of coal (21,000 rail car loads), 1.3 million tonnes of oil (ten million barrels), 30 tonnes of uranium oxide (one rail car load), or one half tonne of the hydrogen isotope of deuterium (one pickup truck load).

Since ocean water contains deuterium, a fuel for fusion, the energy available with fusion is relatively limitless.

Fusion is the process that goes on in the Sun and the stars, as the light elements collide at high speeds and high densities. In both the Sun and the laboratory, ultra-high temperatures (50–200 million degrees) strip the negatively charged electrons from the nuclei, resulting in a highly charged state of matter called a plasma, in which any material can be manipulated at its atomic level. To fuse atoms in the laboratory requires not only ultra-high temperatures, but also a means of containing and controlling the reaction, sustaining it at a steady rate over a long period of time.

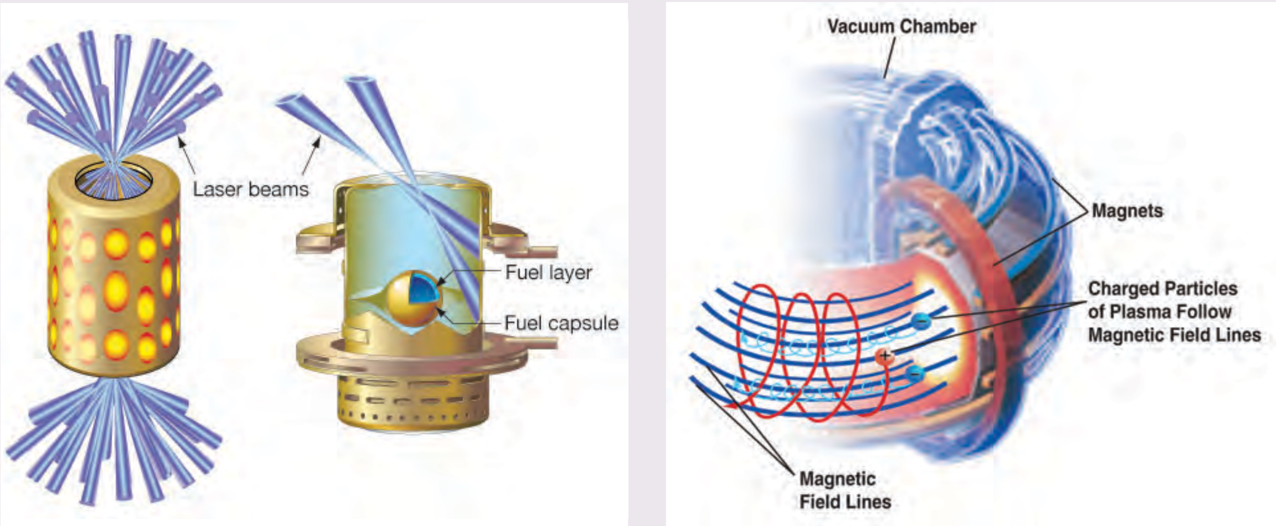
Since the 1950s, scientists have explored different ways of heating and confining hydrogen nuclei to fuse atoms of the heavier hydrogen isotopes, deuterium (^2H) and tritium (^3H). Many proposals for devices and processes have been explored (tokamaks, stellarators, the ELMO bumpy torus, the z-pinch, to name a few). The two prevailing methods to control fusion are known as magnetic confinement and inertial confinement, both of which are embodied in the fusion research continuing today.

Progress in fusion research can be expressed in terms of increasing the "Lawson criterion," the product of plasma density, confinement time, and plasma temperature. The past several decades of research, despite chronic underfunding, have seen a 10,000-fold increase in this parameter. To make the breakthrough to commercial fusion requires a further increase of only about 10 times.



"The Surprising Benifits of Creating a Star," U.S. Department of Energy, 2001.

One type of fusion reaction: two isotopes of hydrogen, deuterium and tritium, combine to form a larger helium nucleus and a neutron, releasing energy in the process. Conditions of at least 100 million degrees under sufficient pressure are required to produce fusion.



Left: Lawrence Livermore National Laboratory; Right: "The Surprising Benefits of Creating a Star," U.S. Department of Energy, 2001

Left: This schematic of the National Ignition Facility shows its array of laser beams focussed on the tiny pellet of fusion fuel encapsulated in beryllium and carbide. The laser beams compress and heat the fuel pellet in a billionth of a second, so that the deuterium and tritium fuse before the pellet flies apart. The term "inertial" refers to the fact that the atoms must have enough inertia to resist flying apart before they combine. Right: This diagram of a fusion tokamak shows the magnets, the magnetic field lines, and the charged particles of plasma that follow the magnetic field lines, spiralling around the tokamak. The magnetic fields "contain" the plasma.

earth moving. Today, PNE technology can be improved and applied for rapidly accelerating and cheapening the construction of vital projects, like NAWAPA XXI.

For materials processing and natural resources, the plasma torch, operating at temperatures below that required for fusion, can break down and separate many materials into their constituent elements and isotopes, meaning that chemical and nuclear "waste" can be processed into valuable resources. Such plasma torches can be a driver towards the higher densities of power achievable with a self-sustaining fusion reaction, at which point we could theoretically extract many times the current annual U.S. production of iron, copper, aluminum, and many other resources from virtually any cubic mile of dirt, and reprocess the valuable concentrations of materials in landfills.

Beyond separation and concentration of resources, a fusion economy allows for the creation of completely new materials with new properties, and even the transmutation of one element into another. For example, petawatt lasers have already demonstrated the ability to transform gold into platinum, and future transmutation potentials are much broader. Thus, the fusion economy demonstrates beyond a doubt that, for an advancing mankind, there are no limited resources, and no limits to growth.

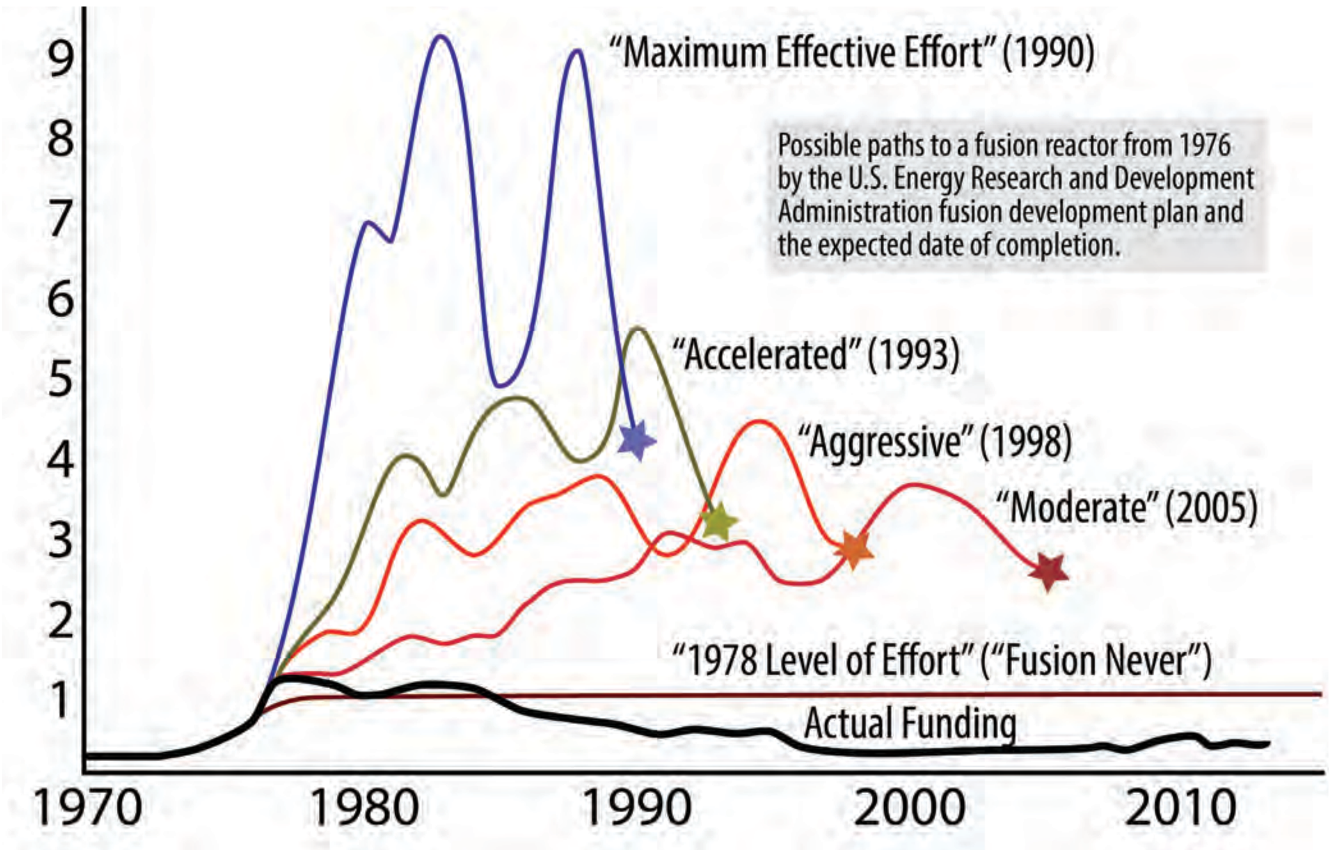
While the broad-based implementation of some of these systems will require a generation or more of work, their future realization depends upon getting started now, and the first steps of a fusion economy are closer than you may think.

1. A Call for An International Manhattan Project

The slow progress in developing fusion power over the past four decades has been the result of political decisions, not scientific impossibilities. For example, in 1980 the U.S. Congress passed Congressman Michael McCormack's "Magnetic Fusion Energy Engineering Act," calling for a crash investment in fusion, and for the construction of a prototype magnetic confinement fusion reactor by the year 2000. However, the breakthroughs were never made because the program was simply never funded, as is indicated in the following graph of the annual fusion budget.

Thus, the challenge today is as much political as scientific. The *decision* must be made to develop the fusion economy; with this commitment, and with full funding and support of key governments, an international crash effort can make this a reality.

Fusion scientists from around the world (and especially the remaining veterans of the fusion efforts going back to the 1960s) must be pulled together to properly plan a serious crash program. The purpose of such a scientific gathering is clear: move the accountants out of the room, get the bureaucracy out of the way, and let the scientists



Credit: graphic design by Geoffrey M. Olynyk, incorporating 1976 projections from the U.S. Energy Research and Development Administration, "Fusion power by magnetic confinement: Program Plan," by S. O. Dean.

Four possible funding paths to create a magnetic confinement fusion reactor from 1976, measured in billions of dollars (adjusted to 2012 values). Actual funding falls below all projections, even a steady funding from 1978 levels (which was known to be too little to ever make the breakthroughs needed).

hammer out what must be done from a scientific standpoint. No options should be off the table, including the revival of alternative fusion reactor designs which were shelved for political or budgetary reasons.

With the scientific, technical, and engineering considerations placed clearly on the table, a crash program can begin, pulling together the fusion and high technology resources of the United States, Russia, China, Japan, South Korea, the nations of Europe, and other countries, along with support from existing bodies such as the International Atomic Energy Agency (IAEA).

While this new crash program is being developed and implemented, an array of existing fusion programs can be fully supported and accelerated, including the large international project, the International Thermonuclear Experimental Reactor (ITER), which has been delayed because of lack of funding and poor coordination.

In the United States, greatly increased funding must be supplied to domestic fusion programs, reversing the Obama administration's slashing of the fusion budget. This includes saving the Alcator C-Mod research facility at MIT (the largest U.S. training facility for students studying fusion) and funding the expansion of the fusion research going on at the nation's various national labs, universities, and industries.

Other nations can do the same, as with the advanced work going on in China with their Experimental Advanced Superconducting Tokamak (EAST), in South Korea with the Superconducting Tokamak Reactor (K-STAR), and the joint Russian-Italian IGNITOR project, among others.

These are only a few examples of ongoing work. A full survey of currently existing programs and past proposals must be done from the standpoint of an open-ended international crash program effort. This will lead to a selection of new demonstration and experimental systems to be constructed. (See Table 1 above.)

To read the rest of this Special Report, visit our website:
21stcenturysciencetech.com

The *21st Century Science and Technology* Special Report:

Nuclear NAWAPA XXI: Gateway to the Fusion Economy

The time has come to make a tremendous step forward in our relationship to nature, by making the development of a fusion-based economy, in which we bring the power of the stars under our control, our *primary* long-term physical economic goal. Not a goal to be pursued in isolation, the mental outlook coherent with such an objective demands immediate action on both political and physical-economic fronts.

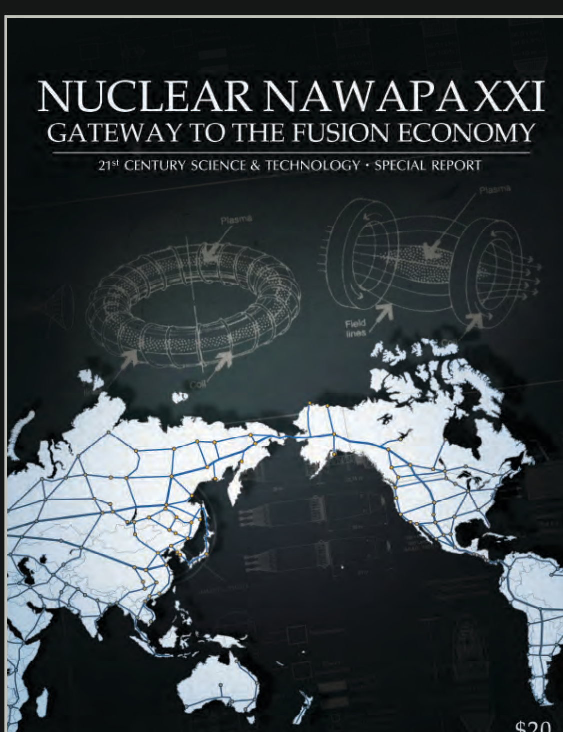
The economic platform encompassing fusion power and our mastery, through the North American Water and Power Alliance (NAWAPA) XXI, of the very geology of our planet—our river systems and our weather—is a coherent goal, one that binds together our greatest aspirations.

While breakthroughs in fusion (given adequate funding) have been possible for decades now, the present historical context does not present fusion as an option, but rather as a necessity.

Any civilization which systemically rejects man's natural development as an increasingly powerful force in nature, will simply be unable to exist.

This Special Report lays out the new economy to be developed with a nuclear NAWAPA XXI driving towards a fusion economy. We begin with fusion, covering the current state of fusion research and nuclear applications besides electricity. The North American water cycle is then covered, demonstrating the water challenges we face and how nuclear power will transform the NAWAPA XXI system. Nuclear agro-industrial complexes offer great potential, where economic planning will incorporate the high-temperature process heat and unique isotopes of nuclear power. We conclude with a proposed Pacific Development Corridor, an example of what international relations should be.

This report provides a full basis for scientists and policy-makers to conceptualize the inspiring future that can be ours, if we grasp it. We are past the point of being able to tolerate the pathological anti-human outlook of those that have held back fusion, fostered the cult-like environmentalist movement, and who teach our children that their goal in life is to have no effect on the world around them. Let us now overthrow the path towards human extinction implicitly (and sometimes, explicitly) demanded by these forces, and be beautifully human. Let us enjoy the thrill of discovery as we do things that are truly new!



Participate in creating the coming fusion economy! Read the new special report, "Nuclear NAWAPA XXI: Gateway to the Fusion Economy," available on the 21st Century Science and Technology website:

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