III. The LaRouche Plan for Mars

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Big Payback From Mars Colony Mission

PART 2

by Lyndon H. LaRouche, Jr.

What follows is the second and final part of this 1988 article. EIR *republished Part 1 in its July 26, 2019 issue.*

Technologies Required for Space

There are three basic categories of scientific-technological progress required for the success of a Mars Colonization program:

1) Controlled electromagnetic plasmas of very high energy-flux densities. The use of controlled thermonuclear fusion as mankind's primary source of power, during the course of the next century, is the usual example of this. Our reference to the "boiling" of tungsten into a plasma-state, illustrates the most obvious sorts of industrial-process designs derived from this line of progress.

2) Controlled pulses of electromagnetic radiation, including lasers as the simplest model, and continuing through very complex electromagnetic nonlinear pulses. This will emerge as the basis of machine-tool design during the coming years. It also affords man the means to control the electromagnetic environment in a general way.

3) The superseding of ordinary molecular biology by new developments in optical biophysics.

All three are aspects of the same, revolutionary development of mathematical physics. All three are currently in progress, being developed, although not rapidly enough. All three are susceptible of measurement in terms of a causal correlation among *technology*, *power*, and *productivity*.

In the space program as such, the development of these technologies has the following, most prominent objectives:

1) When we arrive at Mars, the amount of power required to maintain a synthetic environment (under "domes") suited to permanent human habitation, is more than a decimal order of magnitude greater than in industrialized urban life on Earth today.

2) When we arrive on Mars, and, before that, as we "industrialize the Moon," to supply most of the weight carried from Earth orbit to Mars orbit, we shall require new kinds of industrial extractive and other applications. These are akin to the example we identified, turn-

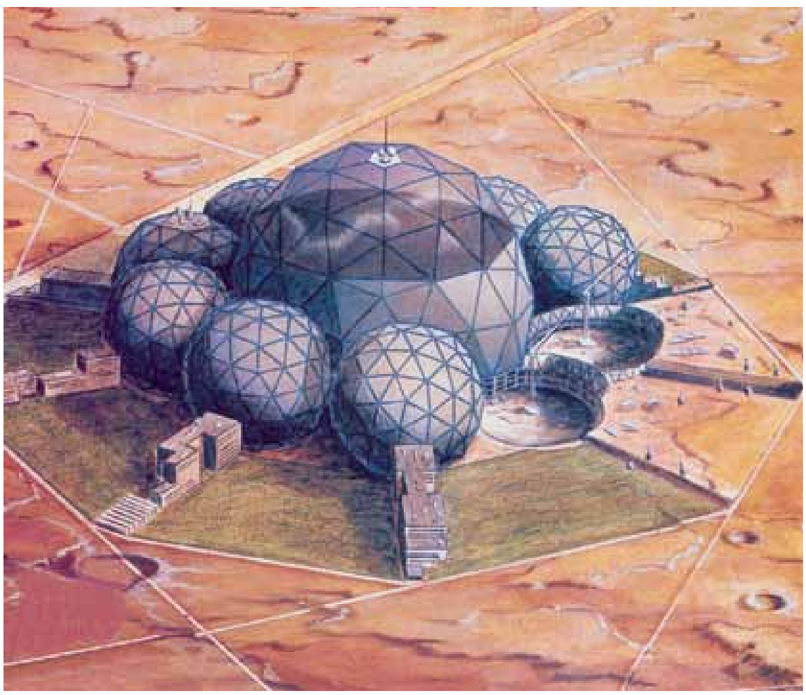


Illustration by Christopher Sloan

An artist's depiction of an industrialized city on Mars under "domes." The power requirements of such a synthetic environment are far greater than for industrialized urban life on Earth.

ing tungsten into a plasma-state. To accomplish this requires very high power-flux densities built into tools used.

3) On Mars, and in extended spaceflight, we are confronted with new challenges in biology. We must create·artificial environments suited to protect the health of space voyagers and Mars colonists. We must cope with the problems of maintaining plant-life and so forth, in space, and in colonies. Of special importance is the potential for development of new kinds of infectious and other diseases in space and on foreign planets. These problems require advances in optical biophysics.

4) We require new kinds of materials, such as ceramic materials with the kind of "aperiodic" paracrystalline structures first described by Kepler. We have presently a foot in the door respecting the methods of producing these; this is the replacement for the old metallurgical industries, such as steel, in reach during the early future.

For example: As we approach atmospheric and supra-atmospheric speeds of Mach 8 and beyond, ablative and other tricks for combating heat-accumulation in the outer hulls of vessels become of marginal value, and worse. Initially, in the vicinity of the presently technologically feasible Mach 8, this becomes an important factor of cost; at higher speeds, it becomes a physical constraint beyond mere cost considerations. Rather than trying to resist heating effects, we must absorb them in a convenient way. New qualities of materials are part of the key to these solutions.

5) There is a partly known, and also partly incalculable risk, in carrying crew and passengers in extended space flight at micro-gravities for periods of many months. The optimum solution for this, is to base human space travel on trajectories defined by a constant acceleration-deceleration equivalent to one Earth-gravity, or near that. This would reduce lapsed time from Earth orbit to Mars orbit to approximately an average of 48 hours.

See the summary calculations which researcher Heinz Horeis and others pulled together in **Tables 2** and **3**. There is not enough matter available to us to complete such one gravity trajectories by chemical rockets' impulses. The only solution is what we may identify conveniently as a "second-generation" fusion-energy system. This, as Horeis indicates, suggests a propulsive power-unit of one terawatt output, readily feasible in a "second generation" fusion system. This would permit manned space travel in one-gravity trajectories, and the movement of gigantic, unmanned "freighters," using the same propulsion system, at lower trajectories.

6) We must, more immediately, decrease the cost of putting a ton of weight into Earth's geocentric orbit. Our objective should be a cost less than 10% the present ones.

Until we develop this new system, we should continue to use present systems of elevating persons (shuttles) and objects into lower and higher orbits. There is

TABLE 2

Calculation of Velocity and Time of Flight

Distance		Time
	Acceleration 1 g	
30×10^9 m	$v_e = 7.7 \times 10^5$ m/sec	t_e = 77,460 sec= 21 h
200×10^9 m	$v_e = 2.0 \times 10^6$ m/sec	t_e = 200,000 sec= 55 h
	Acceleration 1/6 g	
30×10^9 m	$v_e = 3.16 \times 10^5$ m/sec	t_e = 189,700 sec= 53 h
200×10^9 m	$v_e = 8.16 \times 10^5$ m/sec	t_e = 489,900 sec=136 h

Source: *EIR Quarterly Economic Report*

We assume that the Mars ship accelerates for half the distance, s, with constant acceleration a=1 g, or a=l/6 g, and then decelerates with 1 g, or 1/6 g for the remaining half. With $v=(2as)^{1/2}$, *and* $t=(2s/a)^{1/2}$, *we get for the respective half-distances the values of* v_e *and* t_e *shown above. Note the short flight times: less than 2 days for the shortest distance and 11 days for the longest, compared to 260 days for chemical rockets.*

TABLE 3

Energy-Density of Fusion Fuels Compared to Other Rocket Fuels

Mass (1kg)	Kilowatt-hours	Energy (joules)
Chemical (H_2/O_2)	3.72×10^1	1.34×10^7
Fission	10×10^6	6.5×10^{13}
Fusion (D-D)	25×10^6	9.0×10^{13}
Fusion (D-T)	92.5×10^6	3.3×10^{14}
Fusion (D-^{3}He)	97.5×10^6	3.7×10^{14}

Source: *EIR Quarterly Economic Report.*

work which must be done, which must not wait until the new systems are completed during the 1990s. However, we can not proceed economically, to build the Earth orbit based interplanetary systems, until we have the new systems, modeled upon the work of space-scientist Sänger, which not only reduce the cost by about 10%, but also make possible frequent travel between the Earth's surface and the geocentric orbit in which interplanetary space-stations must be located.

NASA

Artist's concept for a lunar base built through in-situ resource utilization (ISRU) and a form of 3D printing known as contour-crafitng.

As this reporter indicated, in his 1986 proposal, and in the March 1988 half-hour *The Woman on Mars* national TV broadcast, the key to achieving such economies and convenience is a two-stage system, involving a rocket, somewhat like the shuttle, piggybacked onto a scramjet aircraft with a top speed of Mach 8. The piggybacked shuttle will reach low Earth orbit; "space tugs" assembled in low Earth orbit, will carry persons and freight to (Earth-point-stationary) geocentric orbit.

7) Although we should resume the sending of unmanned instrument packages to Mars, we should postpone manned landings on Mars until we have the right systems to do so intelligently and with reasonable safety for space voyagers' health during the round trip. We should adopt as early goals, the placing of permanent instrument packages into Mars orbit, and on the surface of Mars. The use of obvious improvements in present reconnaissance satellite technologies will provide us most of the chemical and meteorological information we require for a preliminary Mars survey.

Regular manned flight to Mars requires the preliminary stage of "automated industrialization" of the Moon. This industrialization of the Moon requires rather early development of fusion power and of some of the new kinds of tools indicated. Most of the bulk and weight of space vehicles used for transporting freight and, persons to Mars orbit, must be constructed through the performance of the stages of extraction, refinement, and components fabrication on the Moon, using raw materials available on the Moon.

The entire, 40-year project is organized in a way not unlike the construction of a modern skyscraper. The construction proceeds in planned phases. We develop technologies to meet scheduled times when products based on those technologies must be delivered to begin each next phase of the construction. The research and development, and the industries based on this, are being developed in parallel to the completion of other phases currently in progress of completion.

In other words, we start all phases of the construction now, giving each element of the entire project a time schedule for completion of its development. The early phases must come on line earlier; the later phases have, variously, 10, 20, 30, or 40 years, approximately, to complete their part of the task. This also means, that we begin training high-school and college students now, for the kind of work required of each element and phase of the project. It also means, we begin to assemble the scientific and management teams required for the project as a whole, and each phase and element of the project.

In this sense, the project uses the principles of management proven earlier in development of transportation infrastructure, skyscrapers, and so forth. It means going back to the sound principles of industrial management, in which we used to be among the world's leading nations, and applying those lessons of past experience to the kinds of technologies this project introduces.

The Purposes of the Colony Itself

The Horeis calculations shown here, point to our need for a scientific revolution which carries mankind beyond the limits of fusion power. Putting the point crudely: How much power can we extract from a ton of fusion fuel? For reasons implicit in the calculations, manned space travel along one-gravity trajectories would limit round trips based on the fuel carried out by the vessel, to the vicinity of the Asteroid Belt! How do we break through this barrier?

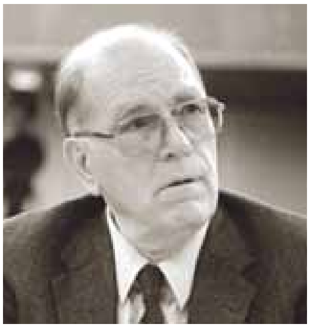
(One obvious solution, is to send low-trajectory space tankers out ahead of the manned craft. The manned craft can then be refueled at such space-based "filling stations." A useful trick for manned exploration of the outer Solar System, but not really a solution to the problem we have posed.)

To any astrophysicist, the nature of this limit is most fascinating. In Kepler's system, as checked by modern physics calculations, the Solar System is divided into two principal regions (excepting Pluto). There are the inner planets, composed largely of heavier elements, and the outer gaseous giants. The division between the two zones, is the Asteroid Belt. If we correct Kepler's calculations of the harmonic values associated with the orbits of the Sun and planets, if we set the Sun at C below Middle C, the band which is the asteroid belt has two rims, of which the innermost rim is at F above Middle C, and the outermost rim at F-sharp: This is the normal bel canto voice register shift for the soprano voice.[1]

There is nothing occult in this. If we correct Kepler's calculations from the standpoint of the nineteenth-century work of Gauss, Riemann, et al., we understand the necessary reasons for this limit of fusion-powered manned space travel within the Solar System. Our understanding of this is greatly improved by recent experimental confirmation of this reporter's longstanding hypothesis, that subatomic space is harmonically ordered in the way indicated by a Gauss-Riemann correction of Kepler's construction of the harmonic ordering of the Solar System. Our insight is improved still more, by current work in progress, reconstructing the periodic table of chemical elements and their characteristic properties, on the basis of this experimentally confirmed hypothesis on the organization of subatomic physical space-time.[2].

Lyndon LaRouche

From a nationwide half-hour television broadcast titled The Woman on Mars *March 3, 1988.*



Thirty-nine years from now, we shall hear the broadcast from Mars, announcing that the first permanent colony there is operational. Among those colonists will be some of the children and grandchildren of you watching this broadcast tonight. Many of you will be watching that first television broadcast from the colony.

Already, the woman who will speak to you from Mars has just recently been born somewhere in the United States. We shall give our nation once again that great future which our children and grandchildren deserve.

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1. Kepler showed that his system required the former existence of a planet in what we identify as the orbit of the Asteroid Belt, today. This was approximately 200 years before the existence of any asteroid was discovered. Kepler showed why, according to his construction of the entire Solar System, any planet in that orbit must have been tom apart. He supplied what later proved to be the correct harmonic values of the orbits for the asteroids. This later proof has the effect of being a conclusive proof of the correctness of Kepler's astrophysics, and a crucial experimental disproof of the approach represented by Galileo, Descartes, Newton, et a1.

2 . On the basis of the experimental confirmation of this reporter's cited hypothesis, Prof. Robert Moon directed an investigation of the way in which the possible elements and isotopes of the periodic table must necessarily be determined. This determination depends upon defining the allowable number and theoretical positions of protons and neutrons in the atomic nucleus; this, in tum, determines the electron structure. The conventional ideas of "gravitational" and analogous "packing" of the atomic nucleus, are discarded. Possibly, a Beltrami space of negative physical space-time curvature is helpful in unraveling this a bit more.

The relevant point in the text is, that the indications of a conformal harmonic ordering of the physics of the periodic table with the composition of the Solar System, argue that the fusion reaction reflects the harmonic characteristics of Earth's spectrum of periodic table at one gravity on the Earth's average surface. The coincidence of fusion power's theoretical limits with the "voice register" phase-shift in the composition of the Solar System, is a stunning fact, but not properly a surprising one.

The question is so posed: Is there not another kind of energy-reaction, which has a much higher energy-mass relationship sufficient to permit a round-trip beyond the Solar System, perhaps?

Experimentally, we know of one such reaction, the socalled “matter, antimatter” reaction.

There are some problems. The standard view of this reaction is based on relevant, but effectively contested dogmas advanced by Dirac—the so-called “Dirac Sea” hypothesis. No matter, we know that the reaction is constructible experimentally; it exists. Therefore, if there is an urgent reason for mastering this reaction, as a controlled reaction employed as an “energy source” by mankind, we must proceed to settle the unresolved theoretical and related questions.

This is one, if only a leading example of the key missions for which we require the assistance of the permanent Mars colony.

Although Earth has no urgent industrial or related need for controlled “matter, antimatter” reactions today, during the second half of the next century, this will begin to appear as a practical problem. This will occur during the lifetime of the grandchildren of the children of this reporter’s nieces and nephews. This will begin to be seen as an upcoming problem for Earth at about the same time the scheduled Mars colony has settled in. So, this will be a leading research mission for that colony from the beginning of its existence.

During the second half of the next century, mankind will look at second-generation fusion energy with not only satisfaction, but also frustration. The increase of our planet’s population-density will require that we become able to use the available land-areas with vastly greater efficiency than today. To develop the technologies, which make mankind’s average lives not only wealthier, but more pleasant aesthetically, we must pay attention to the causal relationship among technology, power, and productivity. The fact that even second-generation fusion energy is a form of power with an upper limit, will be of concern to us on Earth, increasingly, during the second half of the coming century, and will become urgent during the course of the century following that.

If we look back, to the process of technology over the recent five centuries, even the past hundred years, we realize that our population-density of today could not be mastered successfully but for fundamental scientific discoveries of more than a hundred years ago, and, thus on the scientific discoveries established up to more than a hundred years before that.

To develop what we call the “matter, antimatter” reaction, as a controlled primary source of energy for mankind, by the end of the coming century, if not earlier, we must start the work of fundamental scientific discovery today, lest our great-grandchildren, and great-great-grandchildren curse our memory for our failure to do so. Fundamental scientific revolutions, such as this one, take a great deal of time; progress in fundamental scientific discoveries is measured in generations of the adult working-lives of entire generations of scientists.

We may not solve the problem during the lifetime of any working scientists living today. However, by about the time the Mars colony is settled in, that generation of scientists must be equipped to attack the problem with a solution in sight during the lifetime of the generation of scientists following them.

“Pie in the sky”? No. As we have already indicated, our present generations, even during the 1990s, will begin to enjoy immediate benefits, as technology spill-over into higher productivities and so forth, the which they would lack otherwise, unless we proceeded along these lines. Perhaps more important: Is it not a very good thing, to close one’s eyes on the last moment of one’s mortal life, knowing that one’s great-great-grandchildren will have good reasons to smile on the memory of one’s own mortal life? Is it not a very good thing, to be able to live one’s life, during the decades before one’s death, even during adolescent preparations for adult life, knowing that the work which one is assisting is leading to a happy thought about one’s entire life, at the moment of one’s death?

For what other purpose do we bring children and grandchildren into this world, and nurture the development of their moral character and intellectual powers? If we are wise about the living of this mortal life, do we not reflect upon the debt we owe to generations before us, many generations? Do we not reflect upon the fact, that after our life is ended, those who come after us will benefit from what we have contributed to the development of the moral character and intellectual powers of our children and grandchildren?

In the existence of mortal mankind, over hundreds of generations before us, and hundreds perhaps to come, what gives meaning to this tiny speck which is our own mortal existence? What mission might we per-

NASA

To solve the problems that lie ahead for mankind, we must start the work of fundamental scientific discovery today, lest future generations curse our memory for our failure to do so. For what other purpose do we bring children and grandchildren into this world, and nurture the development of their moral character and intellectual powers? Shown, children fascinated by an X-ray mirror cylinder.

form, with this so tiny thing, our mortal existence, that we might look upwards to the heavens, and say to an unseen presence there: "I am happy, because I know that what I am working to accomplish makes my mortal existence a necessary life in the whole space of hundreds of generations before mine, and hundreds of generations still to come"? Can there be greater happiness than to live in such a way as to know, that one's existence is efficiently justified by the mission to which one's mortal existence is contributing?

Security and happiness in our immediate life are necessary conditions for the citizen, to which our Constitution's Preamble dedicates the functions of our federal government. Yet, where could there be true individual happiness, if all the meaning of our having lived were buried with our corpse? Do we not owe ourselves, our children, and humanity, something better than individualistic "materialist" gratifications? Is trudging to and from the securing of one's income, enough, even if the material standard of life secured so is better than adequate? To what higher purpose do we trudge so? Must we not be contributing, in some way, to building something which is good for the future?

We speak of the high value our culture places upon the sacredness of individual life, and respect for the freedom of that individuality. What do we mean by such words? What ought we mean, if we reflect upon the meaning of our mortal lives with a bit more wisdom? Hopes of an after-life may be happy ones, but the conditions in that after-life as such, are matters of faith, not something intelligible to mortals. Is it not the case, that what we do with this mortal life we have defines the measurement of merit placed upon our identity by the Creator? If we do the Creator's Will in relevant matters which are intelligible to mortal minds, can we doubt that the loving eye turned upward to the Creator in that moment, knows what practical thing on Earth such love commands us to do? Is not what we do respecting matters which are intelligible, the which is the expression of our conscience, that good conscience which is the state of true, deeper personal happiness?

The same reflections assume a somewhat different, practical form, as we shift the locus of such questions to the matters of policies of government.

Society, especially as defined by the sovereign republic our Declaration of Independence and federal Constitution, combined, founded us to become, is, as the Preamble of that Constitution avows, an included commitment to care for the well-being of our posterity, at the same time that the existence of the republic serves the current obligations of this federal Union. The nation so defined, is much more than the whims of capricious contemporary majority opinion might imply. It is our debt to preceding generations and to our posterity over indefinite numbers of generations to come. The nation is properly defined as not less than that total population which has been, which is, and which might come to be if we today do not ruin this nation with foolish, capricious whims of momentary popular opinion.

That view of the nation—our republic, is the state of mind of the true statesman. Whoever lacks that standpoint, is no true statesman, however foolishly we might honor as statesman one who lacks that controlling element of conscience. The future we are building with our policies and efforts of today, is the central concern of the true statesman, and of all others worthy of being regarded as "natural leaders" among the rank and file of our citizens.

To the citizen who grasps this moral point, we say we are addressing their deepest concerns, their rightful pursuit of true happiness. To the mere pragmatists, we say the simpler thing: "This will make your lives more meaningful, as well as more secure and prosperous than under any different sort of policy in sight."

We know already, how this challenge of controlled "matter, antimatter" reaction can be mastered during the span of time we have indicated it must. This reporter's principal contributions to economic science were based on solving that kind of problem. The exposition of this is profound, but simple; it is the basis for any correct approach to national science policy. Therefore, we summarize it at this point.

In mathematics, we say, that to the degree mathematical-physical knowledge is deductively consistent, all theorems of current scientific knowledge can be represented by a deductive theorem-lattice derived from an underlying set of Euclidean-like axioms and postulates. Mathematical physics is never fully consistent in that way, but all using deductive method center their work around the attempt to render it consistent in the sense of a deductive theorem-lattice. So, most disputes in science, especially those bearing upon correcting popularized errors of scientific education, or fundamental scientific discoveries, approach scientific matters with the idea that mathematical physics ought to become consistent.

Assuming either that mathematical physics is consistent, or is working to become so, what happens to a mathematical physics developed as a deductive theorem-lattice, when some crucial experiment demonstrates that one or more of the accepted theorems of that lattice are false? A short examination of this is key to defining properly the mission of the Mars colony.

The well-known characteristic of any deductive theorem-lattice, is what is called the "hereditary property." This signifies, that no theorem of such a lattice contains anything which was not implicit in the underlying set of axioms and postulates upon which the lattice as an entirety is based, and from which each and every theorem is directly, or implicitly derived. Therefore, a crucial experimental proof, that one or more of those theorems is false, proves that at least some part of the set of axioms and postulates is also false.

In a rigorous scientific practice, the immediate result of such a series of crucial experiments is, that the set of axioms and postulates must be corrected in ways which are in agreement with the results of these experiments. This leads us to the following procedure.

For easier reading, let us designate the theorem-lattice so refuted by a crucial experiment, as Lattice A. Once we change the axioms and postulates of Lattice A, in such a way as to correct for the error discovered, we have created an entirely new set of axioms and postulates. Every theorem in Lattice A must now be rewritten in such a way as to be fully consistent with the new set of axioms and postulates. The result we may designate as Lattice B.

In practice, it is not quite that easy. There may be a variety of changes in axioms and postulates of Lattice A, each differing from one another, but all apparently in agreement with the results of the crucial experiment. Each of these choices imply the construction of a corresponding Lattice. That means that we have a series of new Lattices from which to choose: B, C, D, and so on. What we must do, obviously enough, is to see which of these, either B, or C, or D, and so on, fits all the scientific evidence, not only the evidence of the particular crucial experiment which set this process of reexamination into motion.

The successful choice of either B, C, or D, for example, as the best new, experimentally consistent theorem-lattice of formal mathematical physics, is what we commonly identify as a "scientific revolution." Those kinds of crucial experimental discoveries are called "fundamental discoveries," and the reconciliation of this fundamental discovery with the larger body of mathematical physics is termed a "scientific revolution."

This is what we confront when we set out to accom-

Ronald Reagan

Excerpts from the speech by President Reagan at the Johnson Space Center in Houston, September 22, 1988.

In the next century, leadership on Earth will come to the nation that shows the greatest leadership in space. It is mankind's manifest destiny to bring our humanity into space, to colonize this galaxy.

In the limitless reaches of space, we will find liberation from tyranny, from scarcity, from ignorance, and from war. I say that America must lead. The nation that has achieved the greatest human freedom on Earth must be the nation to create a humane future for mankind in space, and it can be none other.

Soon the world will be watching as five brave Americans lift off from Earth on the Space Shuttle *Discovery*. America is going to space again and we are going to stay. When *Discovery* takes off, seven precious souls will soar beside it, the seven heroes of the *Challenger*. With their lives, they moved a nation, they summoned America to reach higher still, and they wrote man's destiny into the stars.

Ill fortune can slow us down, but it cannot stop us. You can delay our long trek to greatness, but you cannot halt it. How better can we pay tribute to those who came before us than by continuing their quest for knowledge, their struggle against limits, by continuing to push to the far frontier?

We are a nation born of pioneers and we will always create our future on the frontier. Americans can live no other way. Our early settlers knew great risks and made great sacrifices, and moved the frontier forward to build a great nation. Neither can we stand still, nor be content, and we are not afraid.

Somewhere in America, there is alive, today, a small child, who, one day, may be the first man or woman ever to set foot on the planet Mars, or to inhabit a permanent base on the Moon.

Let every child dream that he or she will be that person, that he or she may one day plant the Stars and Stripes on a distant planet. You and I know that we are the nation that must do it.

plish a scientific revolution over the generation or so ahead, as we are doing in proposing a mastery of controlled "matter, anti-matter" reactions. We continue with the discussion of such "fundamental discoveries'" effects on scientific work.

Suppose the hypothetical crucial experiment led us to adopt Lattice B as our improved formal representation of mathematical physics. The result would be, that no theorem of Lattice B would be deductively consistent with any theorem of Lattice A, and vice versa, of course. Thus, there would exist a kind of "logical gap" between the two lattices. Another word for such a gap is "a mathematical discontinuity." The closer examination of this kind of "logical gap," or "mathematical discontinuity," has been the center of the issues of method in physical science, and the theory of knowledge in general, since the seventeenth-century attack on Descartes by Leibniz. The roots that dispute even go back about 2,500 years, to the ancient classical Greek discussions of a problem termed "the Parmenides Paradox."

Study of this issue is key to understanding scientific revolutions of the past, and is also key to preparing to effect one of the greatest scientific revolutions in history, during the course of the generations just ahead of us.

One of the most famous among the relatively modern statements of this problem is the central feature of Immanuel Kant's *Critiques*. The central feature of Kant's false reasoning, is his assertion that we can not construct an intelligible picture of the kinds of mental processes by which a valid fundamental scientific discovery is accomplished. Kant said such things were "unknowable."

This reporter's original contributions to a science of physical economy were prompted as a reaction to some absurd ideas about "information theory" popularized by Professor Norbert Wiener and John von Neumann, but Wiener's and von Neumann's blunders were merely imitations of the false reasoning of Kant. A refutation of Kant's blunder suffices to disprove modern "information theory" conclusively. It was also the starting-point for this reporter's original discoveries in physical economy.

Kant's cited dogma was based on a false interpretation of the problem of theorem-lattices which we have just described above. He argued along the following lines. Let us assume the case, that the amount of change in the set of axioms and postulates of Lattice A, to generate Lattice B, is of the smallest possible degree. From Kant's vantage-point, in this case, the logical gap between the two lattices exists, undeniably, but no intelligible picture of the gap itself is possible.

The opposite approach, by Leibniz, by such founders of modern science as Nicholaus of Cusa, Leonardo da Vinci, and Kepler earlier, and by such as Bernhard Riemann later, was based on the method of the Socratic dialogue, as typified by Plato's dialogues. In those dialogues, a proposition is adopted for examination. The approach taken is, first, to identify the underlying assumptions on which that choice of proposition is based, and then, in tum, to examine the assumptions underlying the first set of assumptions. The second set of assumptions has the character of a set of axioms and postulates. Change of a false assumption in the second set, is then the basis for supplying a corrected, alternative form of the proposition.

This was the method used explicitly by Leibniz to effect some of his fundamental discoveries. Obviously, contrary to Kant, the processes of creative discovery are intelligible.

Later, during the nineteenth century, the work of Gauss, Dirichlet, Riemann, and Weierstrass showed us how to deal with this kind of lattice-work discontinuity among deductive systems of thought, in a systematic mathematical way. This was key to this reporter's proving that the organizational process associated with Leibniz's definition of *technology* could be represented in the manner referenced above.

On the basis of those principles of technology, we are able to predetermine certain of the most crucial features of a next set of fundamental scientific discoveries. We do not have those discoveries in hand; far from it. What we do have is nonetheless of great practical value to us. We know the general form of the discovery, and we also know the general nature of the experimental investigations which lead us in the right direction.

Happily, much of the preparatory work toward our next major scientific revolution was already completed more than a hundred years ago, by such scientific workers as the already cited Gauss, Dirichlet, Riemann, Weierstrass, and Cantor, and also an Italian collaborator of Riemann's, Eugenio Beltrami. The experimental confirmation of the correctness of their approach, in work done over the recent hundred-odd years, leaves no reasonable doubt, but that this is the correct approach to our next major scientific revolution, and that this can be a successful undertaking within the time-frame we have suggested here.

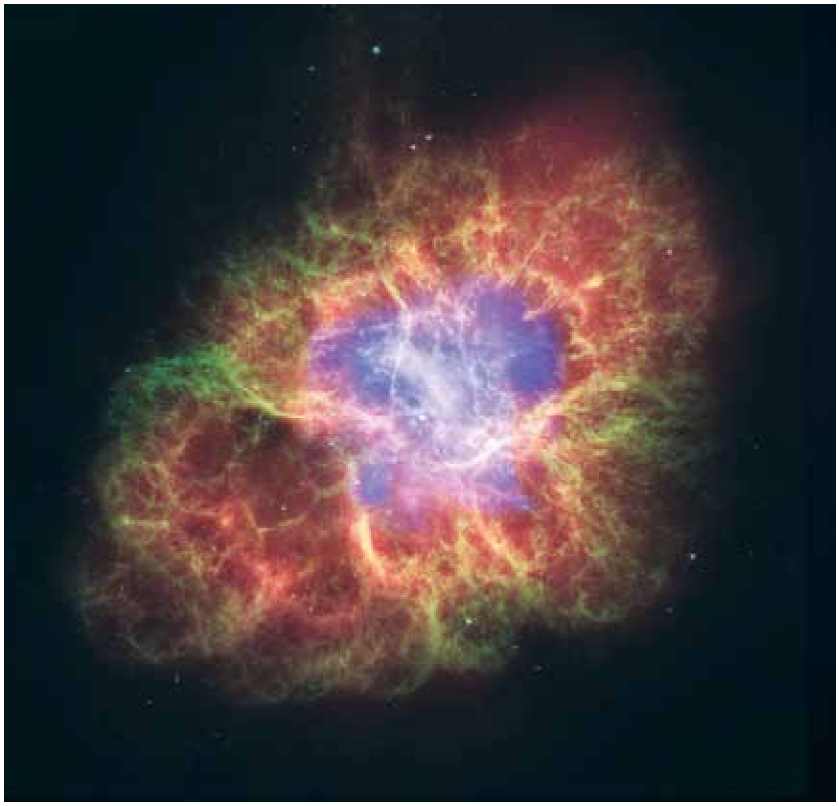
What we must do, obviously, includes intensive study of important physical phenomena which contradict all generally prevailing ideas of physics today. There are three areas on which we must concentrate: astrophysics, microphysics, and optical biophysics. These are, so to speak, always the outer limits of experimental knowledge; it is by proving that newly discovered laws are consistently applied to the areas of these three experimental limits, more or less equally well, that truly fundamental scientific discoveries have been accomplished in the past centuries, and will be by the future generations of scientific workers. In these areas, the kinds of impudent phenomena we referenced, are termed "physical anomalies." They are phenomena which exist, without doubt, and yet their existence defies generally accepted scientific thinking.

Therefore, in effecting the scientific revolution which a controllable "matter, antimatter" reaction implies, we must concentrate, on the astrophysics side, on extremely anomalous astrophysical objects. To do this, we must examine intensively the entire electromagnetic spectrum of the universe, while concentrating special attention on these anomalous astrophysical objects.

This requires putting very large radiotelescopes, up to kilometers or more in effective electromagnetic-optical aperture, into space, as far distant from our noisy Sun as possible. So, the urgency of having a permanent science-city colony on Mars fully operating by the middle of the next century.

This task requires many radiotelescopes, not on Mars itself, but within convenient traveling distance from Mars. Since this will involve thousands of scientists and other specialists to construct and maintain the systems in nearby space, we need a logistical base to support these thousands of specialists. To establish a logistical base adequate to provide the indispensable sort of local logistical support to some thousands of specialists, requires a total population the size of a medium-sized city on Earth. Therefore, that must be a planet suited for building such cities, with synthetic environments, under domes. It must be such a planet as far out from the Sun as practicable for us up through the first half of the next century.

We know already the names and locations of some of the anomalous astrophysical objects to be included on our list. There is the Crab Nebula, a most curious object which supplies us our most intense cosmic ray showers. There are objects sometimes called "black holes," and better called powerful gravitational lenses. There are fast-rotating binary-star systems. And, so on and so forth. We also know, for these cases on such a list, that if we could build radiotelescopes with gigantic aperture, and aim these to collect relevant electromagnetic radiation from these objects and their immediate vicinity, the results would begin to revolutionize science in the laboratories, and also the production lines, back here on Earth.


NASA/ESA/CXC/JPL-Caltech/STScI/Hester, Loll, Gehrz
Composite image of the Crab Nebula, as imaged by NASA telescopes.

We should also desire such devices as gamma ray lasers, or something of that sort, to explore more finely the structure of the atomic nucleus. And so on, and so forth. Optical biophysics study of the way in which nonlinear spectroscopy of coherent radiation governs the molecular and other features of living processes, is also relevant to this same inquiry. The astrophysical research is but one of three general areas of primary investigation on which the next scientific revolution depends

How Our Economy Is Affected

If this reporter had his "druthers," the goals of U.S. employment to be reached by about A.D. 2000 would look somewhat like this.

Not less than 40% of the total labor-force would be employed as operatives in agriculture, industry, and basic economic infrastructure. Presently, the total is less than 20%, where it was about 60% at the beginning of the postwar period.

Not less than 10% of the total labor-force would be employed in research and development, as compared with the goal of about 5% generally accepted 20-odd years ago.

The number of teachers would be increased to not more than 16 pupils per teacher. Medical professionals would be increased as a percentage, similarly.

These changes would come from a combination of sources. To be reduced are the percentage of unemployed, to about 2% "frictional" unemployment, down from a current level of combined reported and officially overlooked unemployment of about 10% or more. Another source of labor for expanding the priority categories, would be a great reduction in redundant employment in administration, sales, and low-skilled services.

The feasibility, and desirability of such changes is indicated by observing the structural changes in composition of employment of the U.S. labor-force during the past 40 years, especially the most recent 20. At the beginning of the period, 40% of total labor-force was employed in "overhead-expense" functions of administration, sales, low-skilled services, and so on. Today, more than 80% is either unemployed, or employed in one of these "overhead expense" categories. Back in the late 1940s, every producing operative carried the cost of eight-tenths of a person on his back, so to speak; today, ignoring purely financial burdens, each productive operative must carry four persons on his back. Little wonder things cost so much, that the real standard of living for a growing majority of our people is falling as it is.

The point is, to reverse the "post-industrial" trends of the past 20-odd years. Government must act to restore incentives for investment in technological progress, and work with the private sector in developing a long-range technological commitment, a commitment which encourages entrepreneurs to invest with assurance of the soundness of that type of investment over the coming 20, 40, or more years ahead.

This means changes in education, obviously.

Look now, at the dynamic of interrelations among research and development, basic economic infrastructure, production of households' goods, and production of capital goods.

The key to injecting technological progress into production in general, is building up the machine-tool sector of employment. This must be matched by strong economic incentives for investment in the new technologies made available through the machine-tool sector.

By rebuilding our machine-tool sector, made up chiefly of small, highly skilled enterprises, we are able to supply the needs to the economy as a whole. The rate at which an expanded machine-tool sector delivers technological progress to investors, is limited by the number of scientists and others engaged in research and development: hence, the build-up of R&D, in all categories of physics and related natural science applications, to about 10% of the total labor-force.

In the industrial sector, there will be an accelerating shift in the composition of employment of operatives. There will be less emphasis on expanding the number of persons employed in production of household goods, and strong emphasis upon upgrading the labor-force into employment in machine-tool and other capital goods sectors. This does not mean a constriction in the supply of household goods per capita; it reflects simply the benefits of increased productivities in the household goods sector.

In infrastructure, apart from educational and health care capacities, the emphasis must be, first, on increasing the supply of power per per-capita unit of population-density. This means a proliferation of construction of modern energy-producing plants. This must be "clean energy," obviously, and must be at relatively high energy-flux densities. The more such installations we construct, and the more rapidly we complete each, the cheaper the costs of construction, and the greater the rate of improvements in quality.

With increased power per per-capita unit of population-density, major improvements in transportation infrastructure are in reach, including the general use of more efficient magnetic levitation rail systems for inter-city and inner-city rapid transit. Inter-city speeds, already, are within the range of 300 miles per hour: One can travel between Boston and Washington, D.C., by magnetic levitation quicker, cheaper, and more conveniently, than by air.

Obviously, we must act quickly on long overdue water-management development. This is key to a general, aggressive approach to building up the natural environment generally. As we know from studies of infrastructure investments during the period 1946-70, expansion of improvements in infrastructure has more direct impact, in such effects as increasing average productivity, than any other form of investment.

So, as long as we take this sort of approach to goals of national employment, and also rebuild our decaying national economic infrastructure to the level which satisfies constraints on technology, a 3-5% improvement in the economy of labor embodied in the design of a new machine-tool, transmits that economy of labor, billiard-ball fashion, throughout the chain of production of producers' and households' goods. This becomes a general increase of the productivity of the economy as a whole.

With those goals, with governmental commitments and investment incentives to match, and with one great, long-range "crash program" in the Mars Colonization project, this nation will readily reach the levels indicated at the outset of this report.