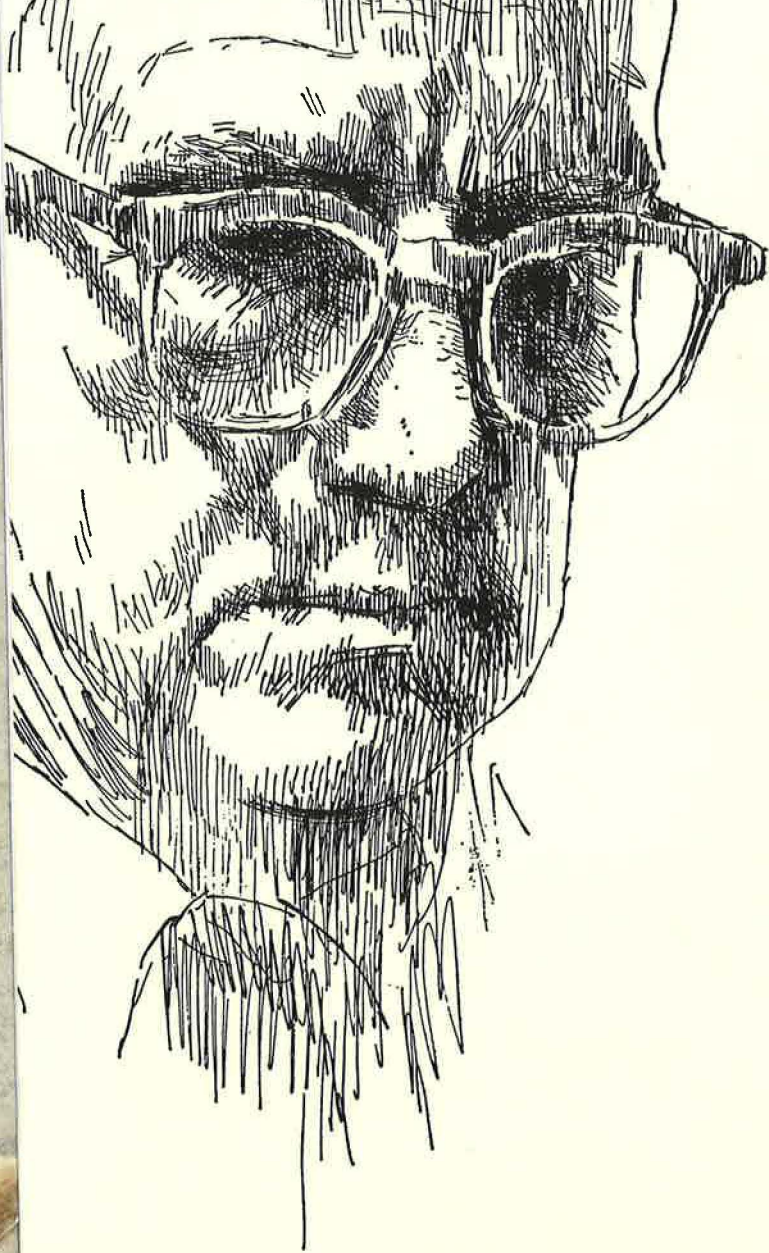


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1969a

Operating Manual for Spaceship Earth

R.Buckminster
Fuller





r. buckminster fuller

operating manual
for
spaceship EARTH



A TOUCHSTONE BOOK

PUBLISHED BY SIMON AND SCHUSTER

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OUR little Spaceship Earth is only eight thousand miles in diameter, which is almost a negligible dimension in the great vastness of space. Our nearest star—our energy-supplying mother-ship, the Sun—is ninety-two million miles away, and the nearest star is one hundred thousand times further away. *It takes approximately four and one third years for light to get to us from the next nearest energy supply ship star.* That is the kind of space-distanced pattern we are flying. Our little Spaceship Earth is right now travelling at sixty thousand miles an hour around the

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sun and is also spinning axially, which, at the latitude of Washington, D. C., adds approximately one thousand miles per hour to our motion. Each minute we both spin at one hundred miles and zip in orbit at one thousand miles. That is a whole lot of spin and zip. When we launch our rocketed space capsules at fifteen thousand miles an hour, that additional acceleration speed we give the rocket to attain its own orbit around our speeding Spaceship Earth is only one-fourth greater than the speed of our big planetary spaceship.

Spaceship Earth was so extraordinarily well invented and designed that to our knowledge humans have been on board it for two million years not even knowing that they were on board a ship. And our spaceship is so superbly designed as to be able to keep life regenerating on board despite the phenomenon, entropy, by which all local physical systems lose energy. So we have to obtain our biological life-regenerating energy from another spaceship—the sun.

Our sun is flying in company with us, within the vast reaches of the Galactic system, at just the right distance to give us enough radiation to keep us alive, yet not close enough to burn us up. And the whole scheme of Spaceship Earth and its live passengers is so superbly designed that the Van Allen belts, which

we didn't even know we had until yesterday, filter the sun and other star radiation which as it impinges upon our spherical ramparts is so concentrated that if we went nakedly outside the Van Allen belts it would kill us. Our Spaceship Earth's designed infusion of that radiant energy of the stars is processed in such a way that you and I can carry on safely. You and I can go out and take a sunbath, but are unable to take in enough energy through our skins to keep alive. So part of the invention of the Spaceship Earth and its biological life-sustaining is that the vegetation on the land and the algae in the sea, employing photosynthesis, are designed to impound the life-regenerating energy for us to adequate amount.

But we can't eat all the vegetation. As a matter of fact, we can eat very little of it. We can't eat the bark nor wood of the trees nor the grasses. But insects can eat these, and there are many other animals and creatures that can. We get the energy relayed to us by taking the milk and meat from the animals. The animals can eat the vegetation, and there are a few of the fruits and tender vegetation petals and seeds that we can eat. We have learned to cultivate more of those botanical edibles by genetical inbreeding.

That we are endowed with such intuitive and intellectual capabilities as that of discover-

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ing the genes and the R.N.A. and D.N.A. and other fundamental principles governing the fundamental design controls of life systems as well as of nuclear energy and chemical structuring is part of the extraordinary design of the Spaceship Earth, its equipment, passengers, and internal support systems. It is therefore paradoxical but strategically explicable, as we shall see, that up to now we have been mis-using, abusing, and polluting this extraordinary chemical energy-interchanging system for successfully regenerating all life aboard our planetary spaceship.

One of the interesting things to me about our spaceship is that it is a mechanical vehicle, just as is an automobile. If you own an automobile, you realize that you must put oil and gas into it, and you must put water in the radiator and take care of the car as a whole. You begin to develop quite a little thermodynamic sense. You know that you're either going to have to keep the machine in good order or it's going to be in trouble and fail to function. We have not been seeing our Spaceship Earth as an integrally-designed machine which to be persistently successful must be comprehended and serviced in total.

Now there is one outstandingly important fact regarding Spaceship Earth, and that is that no instruction book came with it. I think

it's very significant that there is no instruction book for successfully operating our ship. In view of the infinite attention to all other details displayed by our ship, it must be taken as deliberate and purposeful that an instruction book was omitted. Lack of instruction has forced us to find that there are two kinds of berries—red berries that will kill us and red berries that will nourish us. And we had to find out ways of telling which-was-which red berry before we ate it or otherwise we would die. So we were forced, because of a lack of an instruction book, to use our intellect, which is our supreme faculty, to devise scientific experimental procedures and to interpret effectively the significance of the experimental findings. Thus, because the instruction manual was missing we are learning how we safely can anticipate the consequences of an increasing number of alternative ways of extending our satisfactory survival and growth—both physical and metaphysical.

Quite clearly, all of life as designed and born is utterly helpless at the moment of birth. The human child stays helpless longer than does the young of any other species. Apparently it is part of the invention "man" that he is meant to be utterly helpless through certain anthropological phases and that, when he begins to be able to get on a little better, he is

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meant to discover some of the physical leverage-multiplying principles inherent in universe as well as the many nonobvious resources around him which will further compoundingly multiply his knowledge-regenerating and life-fostering advantages.

I would say that designed into this Spaceship Earth's total wealth was a big safety factor which allowed man to be very ignorant for a long time until he had amassed enough experiences from which to extract progressively the system of generalized principles governing the increases of energy managing advantages over environment. The designed omission of the instruction book on how to operate and maintain Spaceship Earth and its complex life-supporting and regenerating systems has forced man to discover retrospectively just what his most important forward capabilities are. His intellect had to discover itself. Intellect in turn had to compound the facts of his experience. Comprehensive reviews of the compounded facts of experiences by intellect brought forth awareness of the generalized principles underlying all special and only superficially-sensed experiences. Objective employment of those generalized principles in rearranging the physical resources of environment seems to be leading to humanity's eventually total success and readi-

ness to cope with far vaster problems of universe.

To comprehend this total scheme we note that long ago a man went through the woods, as you may have done, and I certainly have, trying to find the shortest way through the woods in a given direction. He found trees fallen across his path. He climbed over those crisscrossed trees and suddenly found himself poised on a tree that was slowly teetering. It happened to be lying across another great tree, and the other end of the tree on which he found himself teetering lay under a third great fallen tree. As he teetered he saw the third big tree lifting. It seemed impossible to him. He went over and tried using his own muscles to lift that great tree. He couldn't budge it. Then he climbed back atop the first smaller tree, purposefully teetering it, and surely enough it again elevated the larger tree. I'm certain that the first man who found such a tree thought that it was a magic tree, and may have dragged it home and erected it as man's first totem. It was probably a long time before he learned that any stout tree would do, and thus extracted the concept of the generalized principle of leverage out of all his earlier successive special-case experiences with such accidental discoveries. Only as he learned to generalize fundamental

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principles of physical universe did man learn to use his intellect effectively.

Once man comprehended that any tree would serve as a lever his intellectual advantages accelerated. Man freed of special-case superstition by intellect has had his survival potentials multiplied millions fold. By virtue of the leverage principles in gears, pulleys, transistors, and so forth, it is literally possible to do more with less in a multitude of physio-chemical ways. Possibly it was this intellectual augmentation of humanity's survival and success through the metaphysical perception of generalized principles which may be objectively employed that Christ was trying to teach in the obscurely told story of the loaves and the fishes.

How may we use our intellectual capability to higher advantage? Our muscle is very meager as compared to the muscles of many animals. Our integral muscles are as nothing compared to the power of a tornado or the atom bomb which society contrived—in fear—out of the intellect's fearless discoveries of generalized principles governing the fundamental energy behaviors of physical universe.

In organizing our grand strategy we must first discover where we are now; that is, what our present navigational position in the univer-

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sal scheme of evolution is. To begin our position-fixing aboard our Spaceship Earth we must first acknowledge that the abundance of immediately consumable, obviously desirable or utterly essential resources have been sufficient until now to allow us to carry on despite our ignorance. Being eventually exhaustible and spoilable, they have been adequate only up to this critical moment. This cushion-for-error of humanity's survival and growth up to now was apparently provided just as a bird inside of the egg is provided with liquid nutriment to develop it to a certain point. But then by design the nutriment is exhausted at just the time when the chick is large enough to be able to locomote on its own legs. And so as the chick pecks at the shell seeking more nutriment it inadvertently breaks open the shell. Stepping forth from its initial sanctuary, the young bird must now forage on its own legs and wings to discover the next phase of its regenerative sustenance.

My own picture of humanity today finds us just about to step out from amongst the pieces of our just one-second-ago broken egg-shell. Our innocent, trial-and-error-sustaining nutriment is exhausted. We are faced with an entirely new relationship to the universe. We are going to have to spread our wings of intellect and fly or perish; that is, we must dare

immediately to fly by the generalized principles governing universe and not by the ground rules of yesterday's superstitious and erroneously conditioned reflexes. And as we attempt competent thinking we immediately begin to reemploy our innate drive for comprehensive understanding.

The architects and planners, particularly the planners, though rated as specialists, have a little wider focus than do the other professions. Also as human beings they often battle the narrow views of specialists—in particular, their patrons—the politicians, and the financial and other legal, but no longer comprehensively effective, heirs to the great pirates'—now only ghostly—prerogatives. At least the planners are allowed to look at *all* of Philadelphia, and not just to peek through a hole at one house or through one door at one room in that house. So I think it's appropriate that we assume the role of planners and begin to do the largest scale comprehensive thinking of which we are capable.

We begin by eschewing the role of specialists who deal only in parts. Becoming deliberately expansive instead of contractive, we ask, "*How* do we think in terms of *wholes*?" If it is true that the bigger the thinking becomes the more lastingly effective it is, we must ask, "How big can we think?"

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One of the modern tools of high intellectual advantage is the development of what is called general systems theory. Employing it we begin to think of the largest and most comprehensive systems, and try to do so scientifically. We start by inventorying all the important, known variables that are operative in the problem. But if we don't really know how big "big" is, we may not start big enough, and are thus likely to leave unknown, but critical, variables outside the system which will continue to plague us. Interaction of the unknown variables inside and outside the arbitrarily chosen limits of the system are probably going to generate misleading or outrightly wrong answers. If we are to be effective, we are going to have to think in both the biggest and most minutely-incisive ways permitted by intellect and by the information thus far won through experience.

Can we think of, and state adequately and incisively, what we mean by universe? For universe is, inferentially, the biggest system. If we could start with universe, we would automatically avoid leaving out any strategically critical variables. We find no record as yet of man having successfully defined the universe—scientifically and comprehensively—to include the nonsimultaneous and only partially overlapping, micro-macro, always and everywhere transforming, physical and metaphysical,

omni-complementary but nonidentical events.

Man has failed thus far, as a specialist, to define the microcosmic limits of divisibility of the nucleus of the atom, but, epochally, as accomplished by Einstein, has been able to define successfully the physical universe but not the metaphysical universe; nor has he, as yet, defined total universe itself as combining both the physical and metaphysical. The scientist was able to define physical universe by virtue of the experimentally-verified discovery that energy can neither be created nor lost and, therefore, that energy is conserved and is therefore finite. That means it is equatable.

Einstein successfully equated the physical universe as $E = Mc^2$. His definition was only a hypothetical venture until fission proved it to be true. The physical universe of associative and disassociative energy was found to be a closed, but nonsimultaneously occurring, system—its separately occurring events being mathematically measurable; i.e., weighable and equatable. But the finite physical universe did not include the metaphysical weightless experiences of universe. All the unweighables, such as any and all our thoughts and all the abstract mathematics, are weightless. The metaphysical aspects of universe have been thought by the physical scientists to defy “closed system’s” analysis. I have found, how-

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ever, as we shall soon witness, that total universe including both its physical and metaphysical behaviors and aspects are scientifically definable.

Einstein and others have spoken exclusively about the physical department of universe in words which may be integrated and digested as *the aggregate of nonsimultaneous and only partially overlapping, nonidentical, but always complementary, omni-transforming, and weighable energy events*. Eddington defines science as "the earnest attempt to set in order the facts of experience." Einstein and many other first-rank scientists noted that science is concerned exclusively with "facts of experience."

Holding to the scientists' experiences as all important, I define universe, including both the physical and metaphysical, as follows: *The universe is the aggregate of all of humanity's consciously-apprehended and communicated experience with the nonsimultaneous, nonidentical, and only partially overlapping, always complementary, weighable and unweighable, ever omni-transforming, event sequences.*

Each experience begins and ends—ergo, is finite. Because our apprehending is packaged, both physically and metaphysically, into time increments of alternate awakesness and asleepness as well as into separate finite con-

ceptions such as the discrete energy quanta and the atomic nucleus components of the fundamental physical discontinuity, all experiences are finite. Physical experiments have found no solids, no continuous surfaces or lines—only discontinuous constellations of individual events. An aggregate of finites is finite. *Therefore, universe as experientially defined, including both the physical and metaphysical, is finite.*

It is therefore possible to initiate our general systems formulation at the all inclusive level of universe whereby no strategic variables will be omitted. There is an operational grand strategy of General Systems Analysis that proceeds from here. It is played somewhat like the game of "Twenty Questions," but G. S. A. is more efficient—that is, is more economical—in reaching its answers. It is the same procedural strategy that is used by the computer to weed out all the wrong answers until only the right answer is left.

Having adequately defined the whole system we may proceed to subdivide progressively. This is accomplished through progressive division into two parts—one of which, by definition, could not contain the answer—and discarding of the sterile part. Each progressively-retained live part is called a "bit" because of its being produced by the progressive binary "yes"

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or “no” bi-section of the previously residual live part. The magnitude of such weeding operations is determined by the number of successive bits necessary to isolate the answer.

How many “bi-secting bits” does it take to get rid of all the irrelevancies and leave in lucid isolation that specific information you are seeking? We find that the first subdividing of the concept of universe—bit one—is into what we call a *system*. *A system subdivides universe into all the universe outside the system (macrocosm) and all the rest of the universe which is inside the system (microcosm) with the exception of the minor fraction of universe which constitutes the system itself.* The system divides universe not only into macrocosm and microcosm but also coincidentally into typical conceptual and nonconceptual aspects of universe—that is, an overlappingly-associable consideration, on the one hand, and, on the other hand, all the nonassociable, nonoverlappingly-considerable, nonsimultaneously-transforming events of nonsynchronizable disparate wave frequency rate ranges.

A thought is a system, and is inherently conceptual—though often only dimly and confusedly conceptual at the moment of first awareness of the as yet only vaguely describable thinking activity. Because total universe is nonsimultaneous it is not conceptual. Concep-

tuality is produced by isolation, such as in the instance of one single, static picture held out from a moving-picture film's continuity, or scenario. Universe is an evolutionary-process scenario without beginning or end, because the shown part is continually transformed chemically into fresh film and reexposed to the ever self-reorganizing process of latest thought realizations which must continually introduce new significance into the freshly written description of the ever-transforming events before splicing the film in again for its next projection phase.

Heisenberg's principle of "indeterminism" which recognized the experimental discovery that the act of measuring always alters that which was being measured turns experience into a continuous and never-repeatable evolutionary scenario. One picture of the scenario about the caterpillar phase does not communicate its transformation into the butterfly phase, etc. The question, "I wonder what is outside the outside-of-universe?" is a request for a single picture description of a scenario of transformations and is an inherently invalid question. It is the same as looking at a dictionary and saying, "Which word is the dictionary?" It is a meaningless question.

It is characteristic of "all" thinking—of all system's conceptioning—that all the lines of

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thought interrelationships must return cyclically upon themselves in a plurality of directions, as do various great circles around spheres. Thus may we interrelatedly comprehend the constellation—or system—of experiences under consideration. Thus may we comprehend how the special-case economy demonstrated by the particular system considered also discloses the generalized law of energy conservation of physical universe.

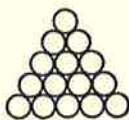
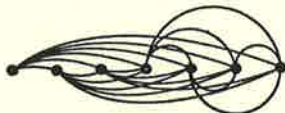
To hit a duck in flight a hunter does not fire his gun at the bird where the gunner sees him but ahead of the bird, so that the bird and the bullet will meet each other at a point not in line between the gunner and the bird at time of firing. Gravity and wind also pull the bullet in two different directions which altogether impart a mild corkscrew trajectory to the bullet. Two airplanes in nighttime dogfights of World War II firing at each other with tracer bullets and photographed by a third plane show clearly the corkscrew trajectories as one hits the other. Einstein and Reiman, the Hindu mathematician, gave the name *geodesic lines* to these curvilinear and *most economical lines of interrelationship between two independently moving "events"*—the events in this case being the two airplanes.

A great circle is a line formed on a sphere's surface by a plane going through the

sphere's centre. Lesser circles are formed on the surfaces of spheres by planes cutting through spheres but not passing through the sphere's centre. When a lesser circle is superimposed on a great circle it cuts across the latter at two points, A and B. It is a shorter distance between A and B on the great circle's shortest arc than it is on the lesser circle's shortest arc. Great circles are geodesic lines because they provide the most economical (energy, effort) distances between any two points on a spherical system's surface; therefore, nature, which always employs only the most economical realizations, must use those great circles which, unlike spiral lines, always return upon themselves in the most economical manner. All the system's paths must be topologically and circularly interrelated for conceptually definitive, locally transformable, polyhedral understanding to be attained in our spontaneous—ergo, most economical—geodesically structured thoughts.

Thinking itself consists of self-disciplined dismissal of both the macrocosmic and microcosmic irrelevancies which leaves only the lucidly-relevant considerations. The macrocosmic irrelevancies are all the events too large and too infrequent to be synchronizably tuneable in any possible way with our consideration (a beautiful word meaning putting stars to-

UNDERLYING ORDER IN RANDOMNESS

No. of Events	Conceptuality of number of most economical relationships between events or minimum number of inter-connections of all events	No. of Relationships $\frac{n^2 - n}{2}$	Closest packed, symmetrical and most economical conceptual arrangement of number relationships.
1		0	
2	 AB	1	
3	 AB, BC, AC	3	
4	 AB, BC, CD, AC, BD, AD	6	
5		10	
6		15	
7		21	
7	 Same number of events could be in random array but minimum total of relationships are same in number.	21	

Sum of Adjacent Relationships (n-1) ²	Conceptuality in closest packed Symmetry Note: This occurs as  "diamonds" and not as  "square".	Sum of Experience or of Events Is Always Tetrahedral
0 + 1 = 1		
1 + 3 = 4		
3 + 6 = 9		
6 + 10 = 16		
10 + 15 = 25		
15 + 21 = 36		

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gether). The microcosmic irrelevancies are all the events which are obviously too small and too frequent to be differentially resolved in any way or to be synchronizably-tuneable within the lucidly-relevant wave-frequency limits of the system we are considering.

How many stages of dismissal of irrelevancies does it take—that is, proceeding from “universe” as I defined it, how many bits does it take—lucidly to isolate all the geodesic inter-relations of all the “star” identities in the constellation under consideration? The answer is the formula $\frac{N^2 - N}{2}$ where N is the number of stars in the thought-discerned constellation of focal point entities comprising the problem.

“Comprehension” means identifying all the most uniquely economical inter-relationships of the focal point entities involved. We may say then that:

$$\text{Comprehension} = \frac{N^2 - N}{2}$$

This is the way in which thought processes operate with mathematical logic. The mathematics involved consist of topology, combined with vectorial geometry, which combination I call “synergetics”—which word I will define while clarifying its use. By questioning many audiences, I have discovered that only about one in three hundred are familiar with

synergy. The word is obviously not a popular word. Synergy is the only word in our language that means *behavior of whole systems unpredicted by the separately observed behaviors of any of the system's separate parts or any subassembly of the system's parts*. There is nothing in the chemistry of a toenail that predicts the existence of a human being.

I once asked an audience of the National Honors Society in chemistry, "How many of you are familiar with the word, synergy?" and all hands went up. Synergy is the essence of chemistry. The tensile strength of chrome-nickel, steel, which is approximately 350,000 pounds per square inch, is 100,000 P.S.I. greater than the sum of the tensile strengths of each of all its alloyed together, component, metallic elements. Here is a "chain" that is 50 per cent stronger than the sum of the strengths of all its links. We think popularly only in the terms of a chain being no stronger than its weakest link, which concept fails to consider, for instance, the case of an endlessly interlinked chain of atomically self-renewing links of omni-equal strength or of an omni-directionally interlinked chain matrix of ever renewed atomic links in which one broken link would be, only momentarily, a local cavern within the whole mass having no weakening effect on the whole, for every link within the matrix is a high

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frequency, recurring, break-and-make restructuring of the system.

Since synergy is the only word in our language meaning behavior of wholes unpredicted by behavior of their parts, it is clear that society does not think there are behaviors of whole systems unpredicted by their separate parts. This means that society's formally-accredited thoughts and ways of accrediting others are grossly inadequate in comprehending the nonconceptual qualities of the scenario "universal evolution."

There is nothing about an electron alone that forecasts the proton, nor is there anything about the Earth or the Moon that forecasts the co-existence of the Sun. The solar system is synergetic—unpredicted by its separate parts. But the interplay of Sun as supply ship of Earth and the Moon's gravitationally produced tidal pulsations on Earth all interact to produce the biosphere's chemical conditions which permit but do not cause the regeneration of life on Spaceship Earth. This is all synergetic. There is nothing about the gases given off respiratorily by Earth's green vegetation that predicts that those gases will be essential to the life support of all mammals aboard Spaceship Earth, and nothing about the mammals that predicts that the gases which they give off respiratorily are essential to the support of the vegetation

aboard our Spaceship Earth. Universe is synergetic. Life is synergetic.

Summarizing synergetically I may conclude that since my experimental interrogation of more than one hundred audiences all around the world has shown that less than one in three hundred university students has ever heard of the word synergy, and since it is the only word that has that meaning it is obvious that the world has not thought there are any behaviors of whole systems unpredictable by their parts. This is partially the consequence of over-specialization and of leaving the business of the whole to the old pirates to be visibly conducted by their stooges, the feudal kings or local politicians.

There is a corollary of synergy which says that the known behavior of the whole and the known behavior of a minimum of known parts often makes possible the discovery of the values of the remaining parts as does the known sum of the angles of a triangle plus the known behavior of three of its six parts make possible evaluating the others. Topology provides the synergetic means of ascertaining the values of any system of experiences.

Topology is the science of fundamental pattern and structural relationships of event constellations. It was discovered and developed by the mathematician Euler. He discovered

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that all patterns can be reduced to three prime conceptual characteristics: to *lines*; *points* where two lines cross or the same line crosses itself; and *areas*, bound by lines. He found that there is a constant relative abundance of these three fundamentally unique and no further reducible aspects of all patterning

$$P + A = L + 2$$

This reads: the number of points plus the number of areas always equals the number of lines plus the number constant two. There are times when one area happens to coincide with others. When the faces of polyhedra coincide illusionarily the congruently hidden faces must be accounted arithmetically in formula.