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NONLINEARITY AND THE BIOLOGICAL SCIENCES

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Cover: The front cover shows a view of the earth from the Apollo II journey to the moon. Nonlinear cloud formations are visible. The same view is presented schematically on the back cover.
Source: NASA

Nonlinearity and the Biological Sciences

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Conference on

Nonlinearity and the Biological Sciences

Sponsored by the Fusion Energy Foundation

Panel I 10AM

Welcoming Address: What is Nonlinearity: The View from Plasma Physics
Dr. Steven Bardwell, *Director, Plasma Physics Division, FEF*

Neural Ensemble Theory and Hierarchical Sets
Dr. Walter Freeman, *Department of Physiology and Anatomy, University of California, Berkeley*

Topological Mapping of the Retina onto the Cortex: Functional and Developmental Implications
Dr. Eric Schwartz, *New York Medical College*

Riemannian Geometry and the Neurological Representation of Time
Dr. Robert Thatcher, *New York Medical College*

Geometrical Transformations and The Question of Development
Dr. Ned Rosinsky, *Biological Sciences Division, FEF*

Discussion and questions: 12 noon

Saturday, May 14
10 a.m. to 9 p.m.
Columbia University

Mathematics Building Room 312
New York City

Admission
Corporation
Representatives $50
Individuals $10
Students .... $ 5

Pre-registration forms can be found on the magazine insert card

Panel II 2 PM

Genetics and Evolution: An Epistemological Critique
Dr. Richard Pollak, *Biological Sciences Division, FEF*

Global Oscillations and Compartmentalization in Embryology
Dr. Stuart Kauffman, *Department of Biochemistry, University of Pennsylvania*

Macromolecular Interactions in Cytoplasm: The Evidence from Nuclear Magnetic Resonance
Dr. Lawrence Minkoff, *Downstate Medical School*

Environmentally Induced Changes In the Genetics of Ribosomal DNA
Dr. Hal Krider, *University of Connecticut*

Energy Throughput and the Development of Weather Patterns
Eric Lerner, *FEF*

Discussion and questions: 4 PM
Dinner: 5 PM

Panel III 6:30 PM

Neurology and Psychology: The Politics of Science
Dr. Hardin Jones, *Donner Laboratory, University of California, Berkeley*

The Tradition of Louis Pasteur
Warren Hamerman, *National Executive Committee of U.S. Labor Party*

Discussion and questions: 8 PM

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EDITORIAL

Toward an Interdisciplinary Science

This issue of the Fusion Energy Foundation *Newsletter*, "Nonlinearity and the Biological Sciences," marks the FEF's first *public* step into the biological sciences.

As *Newsletter* editor I am tremendously excited by the establishment of the Biological Sciences section of the FEF. It is actually as a plasma physicist that I am most enthusiastic about the formation of a group of biologists, agronomists, and medical doctors who are collaborating with the Foundation. I am convinced that the most difficult and fundamental problems in the physical sciences, and plasma physics in particular, are closely related to those in the biological sciences, and that contrary to common belief, the biological sciences are more advanced in recognizing these fundamental problems than the physical sciences. In fact, physical scientists and engineers have already derived the most from the growing common work with these biological scientists.

Self-Organizing Phenomena

In all of these sciences, the central unsolved problem is that of self-organizing phenomena. The self-ordering behavior of living systems is obvious; and the problems such behavior presents in describing reproduction, differentiation, cell biology, neurophysiology, and evolution are well known. Not so well known is the fact (and longtime contention of the FEF) that conceptually similar problems are posed by the highly nonlinear, self-organizing phenomena of solitons, vortices, self-generated magnetic fields (and many others) in high-temperature, high-density plasmas.

This similarity between the biological sciences and plasma physics is no longer speculation. Not only are the mathematical features of the most advanced theoretical biology strikingly similar to those used to describe self-organizing phenomena in physics and chemistry (See the article by Ned Rosinsky in this issue); more important, the conceptual insights that exist in the biological sciences have proved to be tremendously provocative for the solution of similar problems in plasma physics.

In the work I have done with the Fusion Energy Foundation, for example, the contribution from biology to the dynamics of nonlinear, self-ordered phenomena is immense. How is one to understand the fact that almost every high-energy plasma has a tendency to concentrate its energy into highly structured bunches? From the point of view of contemporary physics, such a process, or direction of evolution, is almost incomprehensible in a *systematic* way: Based on an understanding of the Second Law of Thermodynamics and a vast experience with linear systems, every physicist either would disregard any experimental evidence in that direction ("It is an anomaly," "It requires such special initial conditions that it is irrelevant for global processes," etc.) *or*, would regard all nonentropic phenomena as a fluctuation from the underlying entropic evolution of the universe as a whole.

A hard look at the pervasiveness of the self-generated, increasingly complex systems that occur in biology, however, make the physicists' natural reaction suspect. Perhaps they themselves abstract from the most important feature of *all* matter — living and nonliving?

Both physicists and biologists object that it is exactly the question of energy densities (or, more narrowly, temperature) that justifies a division of the universe into physical and biological processes. A plasma is so hot, and living processes can occur only in a very restricted range of temperatures — how can they share the same physics? The point that biology shows so effectively is that there is no a priori energy scale. Rather, the energy-density scale for each process or subprocess is defined internally, or geometrically (in a Riemannian sense). This geometrization is the thoroughgoing coherence between the phenomena in the biological sciences and in physics. A dynamic sense of the intrinsic geometry of a process of development — the methodology that physics is still struggling with — comes naturally out of a study of life.

An ongoing and close collaboration between the biological and physical sciences is essential. As soon as each recognize the intersection of mutual study of nonlinearity and self-ordered systems, the cross-fertilization between the two approaches to the same universe will confront the fundamental difficulties in each. This newsletter is the FEF's first contribution to this interdisciplinary science.

Georg Cantor, the nineteenth century mathematician noted the basic methodological point involved: "The coherence of the two realities (the living and nonliving —ed.) has its true foundation in the unity of the all, to which we ourselves belong as well."

This rigorous methodology — that the entire universe must be subject to description by the same process — is the systematic basis for analogies between the physical sciences and the life sciences. If such analogies do not exist, then our science is at fault.

—Dr. Steven Bardwell

The Overlooked Importance of Pasteur

Warren Hamerman

INTRODUCTION

*The universe is a dissymmetrical totality, and I am inclined to think that life, such as it is manifested to us, is a function of the dissymmetry of the universe or the consequences which it produces** *(1874)*

In returning afresh to review the scientific contributions of Louis Pasteur (1822-95), I intend to reopen several fundamental epistemological questions underlying the biological sciences that are directly oriented toward recent advances in plasma physics. Current advances in the research of high energy-dense plasmas have already confronted scientsts with species of nonlinear effects that exhibit the qualities of right-handed and left-handed structures, helices, "twisted" filaments, and globular forms suggesting unmistakable comparisons to biological phenomena.

The range of problems investigated by Pasteur remarkably outline an appropriate agenda for ordering the collaborative contributions now called for between plasma physicists and biological scientists — with insights and theoretical clarity resulting from a process of interchange flowing in *both* directions.

The thematic aspects of Pasteur's work are threefold:

(1) Pasteur investigated the special geometries appropriate to the "inside" as well as the "outside" of molecular interactions in the chemistries of life. Pasteur's experiments and *Mémoires*, widely circulated throughout Europe, were the first empirical forays into an appropriate spatial theory of molecular chemistry.

For his achievements Pasteur is generally acknowledged to be the forerunner of *stereochemistry* — namely, the idea that during chemical processes molecules may fold and generate different shapes in space while maintaining the same structure and configuration. The reductionist classifies such effects as an epiphenomenon of the molecule. Pasteur's theory of "molecular dyssemmetry," based upon his experiments during the decade 1844-54, converged upon the advanced notion that there existed *in the physical universe a continuous evolution toward biologic "chemistries" of higher and higher mode.*

(2) From 1854 until the middle of the 1870s, Pasteur exhaustively investigated the laws of one such biologic chemistry, that associated with the process of fermentation. He derived a model of biologic interaction that stressed the coherence between processes occurring on the global ecological level, those directly under man's control through industrial development, and those occurring on the molecular level.

Pasteur's "theory of fermentation" represents the biologic and chemical processes occurring as a more primitive form of life cycle than that now predominant in the biosphere. One could thereby postulate correspondents to life under atmospheric and terrestial conditions prior to those found in the modern era. Pasteur's notion that "fermentation is life without air" implies a *notion of evolution that proceeds from the self-development of the biosphere as a whole.*

(3) Overlapping his studies on fermentation, during the years 1863-85 Pasteur formulated the modern "germ theory of disease," establishing the science of *epidemiology* and public health on a firm footing.

The primary theoretical consideration that motivated Pasteur's work on fermentation is generally overlooked or deemphasized. He operated very much in the tradition that human health was developmental. Health is decisively not a mere absence of disease that results from a homeostatic or harmonious balance between man and nature. Rather, *man has the ability to determine for his species a rising metastatic condition of healthier and healthier human beings.* Besides methods for combating specific pathologies through immunization, Pasteur organized for the establishment of preventive medicine.

Pasteur's profound relevance for study today arises from his successful and coherent translation of such insights from the scientific into the political arena. In contradistinction to the despicable Malthusian Charles Darwin, Pasteur fought politically to achieve those conditions in which scientific development would occur: a national commitment to economic expansion based on rapid industrialization and the utilization of new technologies, a flourishing of social investment to fund research for the scientific community, the establishment of an overall policy for advanced scientific education and research centers, and the broadest-based dissemination of scientific ideas and training throughout the general population.

As will become apparent in a discussion of biographical material, Pasteur was a leading organizer of scientific cadre around the task of constantly upgrading the scientific culture of the general workforce. He was concerned with the transformation of the working class into skilled workers and scientific cadre by programs of general scientific education modeled explicitly on those of Benjamin Franklin. Darwin's political concern, on the other hand, was to downgrade the European working class along the lines expressed by the bestial Thomas Huxley in his notorious boast: "By next week I'll have the workers believing they're monkeys!"**

Although it is generally recognized that modern biological science owes an enormous debt to Pasteur, the methodological underpinnings of his work have been cavalierly brushed aside leaving a residue of disparate, banalized discoveries. As indicated by Pasteur's own comments on his work, the suggestive geometric and evolutionary conditions of protoplasm and plasma ought to

*A full translation of "Observations on Dissymmetrical Forces," from which this quotation is taken, appears in the Appendix.

***Thomas Huxley's role as a sponsor, popularizer, and ideological mentor of Charles Darwin is fully documented in the latter's Autobiography* and *Selected Letters* (1887). For a discussion of the Huxley family's role throughout the twentieth century in promoting the proliferation of cognitive-destroying drugs, see "Rockefeller's Biochemical Warfare" (Hamerman and Stahlman 1976).

be taken as an entirely lawful occurrence by any scientist imbued with the modern world outlook of the advanced humanist tradition. The laws of the physical-biological universe are coherent with those laws determined to be appropriate to the development of human creative cognition. The scientific term employed to describe such coherence is *hylozoic monism*, a concept derived in the sixth century BC by the philosopher Thales of Miletus.*

That this notion is within the scope of Pasteur's projects is revealed by the following notebook entry he penned in 1871:

> Show that life is in the germ, that it has been put in a state of transmission since the origin of creation. *That the germ possesses possibilities of development, either of intelligence and will, or — and in the same way — of physical organs. Compare these possibilities with those possessed by the germ of chemical species which is in the chemical molecule.* The possibilities of development in the germ of the chemical molecule consist in crystallization, in its form, in its physical and chemical properties. Those properties are *in power* in the germ of the molecule in the same way as the organs and tissues of animals and plants are in their respective germs. Additionally, nothing is more curious than to carry the comparison of living species with mineral species into the study of the wounds of both, and of their healing by means of nutrition — a nutrition coming from within living beings, and from without through the medium of crystallization in the others (emphasis added).

From the time of Pasteur's death in 1895 through the immediate post-World War I period, the hegemonic scientific conceptions for biological systems (closely following developments in mathematical physics) was that the protoplasmic field was a unique state of matter in which all then-known laws of chemistry and physics were extended to the breaking point. Today, utilizing the most advanced conceptual terminology, we can succinctly address the seeming uniqueness of that state of matter.

A phenomenology of living systems describes self-regulating and self-reproducing processes of high energy density characterized by the differentiation and growth of nonlinear structures. The totality of interactions is appropriately termed ***meta**bolism*. The overall quality of such systems, in which marginal effects determine overall transformations in chemistry, is to continuously generate the capacity to evolve living systems of a qualitatively higher order. Their evolution, therefore, can be described as *negentropic*.

The character of living systems is by no means exclusive to their domain. As we will demonstrate using Pasteur's magnificent experimentation, so-called inorganic, organic, and biological distinctions do not differentiate themselves, one from the other, by virtue of distinct "stuff" in their composition.

It was precisely because Pasteur coherently translated such insights from the scientific into the political arena that he so raised the wrath of the reductionists. For related reasons, Pasteur is generally afforded the same disparaging treatment as Benjamin Franklin. What a criminal episode that simpletons of unfortunate influence have described the scientist Franklin as if he were a mere flyer of kites and Pasteur as a simple heater of wine, milk, and beer, or the inoculator of sheep! The essence of such psychopathologic historians of science — hatched among the enemies of progress who prefer multiplying their paper money to real development — is to besmear through falsification the very basis of all science: man's actual, practical contributions to alter the material universe through scientific discovery.

It is by no means accidental that the victims of such slanders were all committed political partisans in the humanist struggle for scientific progress. The Rothschild, Warburg, and Rockefeller school of scientific history has gone to outrageous extremes to cast the image that Pasteur was even an imperialist and racist because of his commitment to industrial expansion and his hatred of monetarism.** Such ludicrous mythologists and slanderers also tend to label the great chemist and Colbertian political leader, Antoine Lavoisier, as a tyrannical landlord and René Descartes, the epistemological father of modern science, as a hopeless mechanist.

The Reductionist Consequences of Misrepresenting Pasteur

Such butchery of man's creative history breeds disastrous scientific consequences. For much of the twentieth century the biological sciences have been the dormitory for either reductionist theorizing of *the biologic molecule* as a "thing-in-itself" or a pseudo-Kantian abreaction with Malthusian complications.***

The biological sciences, as well as plasma physics, ought to constitute the clearest empirical expression of nonlinearity and negentropic behavior. Living systems absolutely violate the notion of thermodynamic entropy, the standard laws of constant and multiple proportions, the fixed precepts of growth based upon molecular simple additions of carbon or other chain linkups in discrete increments — as well as violating all common sense prejudices against self-reflexive structures in nature.

At the outset it is necessary to cast aside the overly influential and unfortunate formulation of Erwin Schrödinger in the early 1940s — namely that organic-biological systems are characterized by negative entropy whereas the remaining "stuff" in the universe holds to the laws of en-

*Further discussion of hylozoic monism can be found in *Dialectical Economics (LaRouche 1975)*; *"Beyond Psychoanalysis" (LaRouche 1973)*; *The Origin of Life (Oparin 1923)*; *The German Ideology (Marx 1846)*; and *"The Self Development of the Biosphere," (Hamerman 1975)*.

**For example, Robert Reid in his 1974 biography *Marie Curie* (New York: E.P. Dutton) refers to Pasteur as a "jingoist" and a "snob" and implies that Pasteur held back French science by his refusal to accept Darwinism.

***The pseudo-Kantian notion of "holist biology" is associated with the work of Jan Christian Smuts, the British Round Tabler field marshal *(Holism and Evolution)*; J.B.S. Haldane, special advisor for British Intelligence MI-5 (*The Causes of Evolution*); R.A. Fischer, the raving Malthusian (*The Genetical Theory of Natural Selection*); and others emanating from the Theoretical Biology Club of Cambridge University in the early 1920s. Their holist thesis presents a seemingly seductive alternative to reductionism that is actually an even more vicious denial of universals than reductionism per se. In their pluralist epistemology each cell, each atom, and each mind is seen as its own whole — a thing unto itself. The laws of nature as they define them ensure an increasing convergence upon a perfectly ordered empire (equilibrium) with each distinct whole neatly arranged in a hierarchy.

The thrust of the British holist notions laid the basis for biometric and social statistical studies that justified genocide program among so-called inferior subhuman populations in the Third World. Holism was used as the cultural relativist ideology for population control programs by Corliss Lamont's networks in the United States among black populations and for intelligence penetration operations by the Rockefellers into the Soviet scientific community. Others associated with the holist school include mad geneticist Theodosius Dobzhansky of the Rockefeller Institute as well as the even more notorious Arthur Koestler and Ludwig von Bertalanffy.

In the recent period the holist ecology movement has been revived tropy. The ABC of all modern scientific inquiry into the nature of extending human development must emphasize the hylozoic nature of that particular universe that has generated man, or, to be more precise, thinking man.

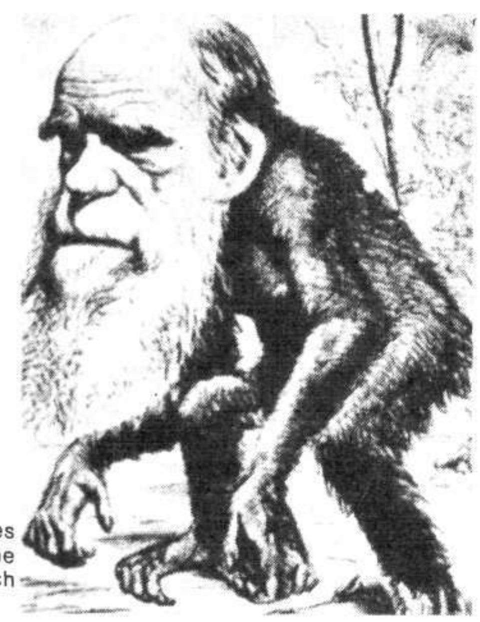
An early but representative expression of the mechanist approach is Albrecht Kossel's 1911 lecture at Johns Hopkins University in Baltimore. Kossel's *bausteine* or building block theory, along with Emil Fischer's "sequence" hypothesis of amino acids and Hermann Staudinger's "macromolecules" degenerate into a Chomskyesque horror show in recent interpretations of the genetic code.*

Kossel's "linguistics" lecture began by comparing the arrangements and recombinations of proteins in the animal or vegetable organism to the making up of a railroad train from its unit cars:

> The number of *bausteine* which can take part in the formation of the proteins is about as large as the number of letters in the alphabet. When we consider that through the combination of letters an infinitely large number of thoughts may be expressed, we can understand how vast a number of the properties of the organism may be recorded in the small space which is occupied by the protein molecules. It enables us to understand how it is possible for the proteins of the sex-cells to contain, to a certain extent, a complete description of the species and even of the individual. We may also comprehend how great and important the task is to determine the structure of the proteins and why the biochemist has devoted himself with so much industry to their analysis.

The development of reductionist biology in the twentieth century is most closely associated with the funding and influence of the Rockefeller family. In the early 1930s Warren Weaver, then director of the natural science program of the Rockefeller Foundation, invented the term "molecular biology," which he defined as the study of "the ultimate units of the living cell." From 1932 to 1959, the Rockefeller Foundation invested more than $90 million in an effort to wed molecular biology to quantum physics. The principal quantum physicists involved in the project to search for ultimate life particles were Max Delbruck and W.T. Astbury in the 1930s, Schrödinger in the 1940s and Francis Crick from 1947.

Their central theoretical output was a linear model to



Cartoon of Charles Darwin from the *Hornet*, 22 March 1871

explain biological specificity. Molecular interactions are linearly coded to fixed, lock-and-key or "template" configurations. These models, outlawing the nonlinear processes that are empirically pervasive in biology, are referred to in the trade as the *central* and *secondary dogmas*. The phenomena discussed in these models are real; what is wanting is a process of higher-order mapping to understand the interactions and their ordering into observed configurations to replace the linear, computer code paradigm. Representative interactions demanding immediate theoretical clarity by qualified specialists are: one DNA, one RNA; one gene, one enzyme, one protein; one antibody, one antigen; one amino acid sequence, and one protein.**

Advances in our understanding of the biological sciences, superseding the dogmas, will occur in conjunction with developments in the domain of plasma physics, along the lines charted by the application of Georg Cantor's notion of

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to enforce the zero-growth economic policies of the Rockefellers. At this moment the Carter administration and other policy vehicles for the bankrupted Rockefeller circle are cynically cutting the funding of crucial research, training, and health programs, at the same time that they parade all sorts of Malthusian rubbish and quackery to justify policies of genocide in the guise of academically accepted biological laws.

Three of the most prominent examples involve: (1) the presentation of so-called reports, experimental data, and studies justifying the criminal proliferation of dangerous, cognition-destroying drugs such as marijuana, cocaine, heroin and methadone; (2) the fostering of phony and incompetent Darwinian theories of ecology which argue that, according to the long-since debunked "law of natural selection," man must engage in a fierce survival-war-of-the-fittest with lower species such as clams, louseworts, snail darters, and other assorted fauna and flora; (3) the deliberate enhancement of gross epidemic holocaust on a global scale through the outlawing of basic public health and immunological programs, *all "exonerated scientifically"* through the pronouncements and policy recommendations of far too many accepted authorities and institutions.

*Under the bogus discipline of "linguistics," MIT Professor Noam Chomsky has been a principal developer of the *brainwashing* technology used by the intelligence community to create so-called zombie terrorists and send them on various hideous assignments.

The computer technology languages in which Chomsky specializes take as their fundamental premise that the universal quality of *human creative mentation* is nonexistent. The linguistics approach is oriented toward the inducement of an "artificial intelligence" in the victim. The clinical state of mind that results from a process of "programming" under an aversive environment is paranoid schizophrenia. The brainwashing victim undergoes a complete mental collapse, adopting infantile emotional patterns. Words, phrases, and gestures take on purely *magical* and *mystical powers* that then control the victim's behavior.

The development of the "codon" theory of information transfers in human genetic material since World War II (work supported by immense Rockefeller funding) closely parallels the incompetent model of human "artificial intelligence" developed by the Chomskyesque linguisticians. See "Linguistics: A Tool of the CIA's Global Terrorism" (LaRouche 1976 "PsyWar! The Science Versus the Art" (LaRouche 1976); and "Artificial Intelligence" (Gallagher 1975).

**There has been a fairly substantial development of the dissymmetry question in the twentieth century, albeit in a formal and paradoxical way. In 1874 the Dutch physical chemist van't Hoff (1852-91) and the French chemist Le Bel (1847-1930) established the rules of stereochemistry. Their work focused on unraveling the properties of dissymmetric carbon structures in space, which provided the explanation for the optical activity of organic structures that results from the peculiar bonding attributes of the carbon atom. Laevo (L) and dextro (D) forms of isomers, the two alternate spatial configurations, are possible if the four the *transfinite* to the physical laws of a Riemannian continuum.*

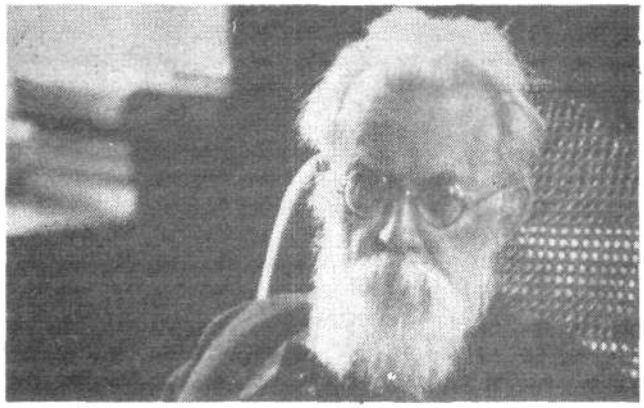
Reducing the Reductionists

To reach such theoretical territory, it is first necessary to regenerate a systematic polemic against both reductionist and pseudo-Kantian interpretations of biological processes. Earlier in this century there was indeed such a polemic, developed *in the tradition of Pasteur.* Oparin's classic work *The Origin of Life* (1923) emphasizes the critical features:

> The theories attempting to explain the properties of living matter on the basis of some specific radicles in the protein molecule are untenable. Attempts to deduce the specific properties of life from the manner of atomic configuration in the molecules of organic substance could be regarded as predestined to failure. *The laws of organic chemistry cannot account for those phenomena of a higher order which are encountered in the study of living cells.* The structure of the protein molecule, its amino and carboxyl radicles, polypeptides or other linkages, etc., determine only *the ability of this material to evolve and change into a higher grade of organization, which depends not only on the arrangement of atoms in the molecule but also on the mutual relationship of molecules towards one another* (emphasis added).

Establishing the basis for Oparin's later work, Pasteur's research spanned the full spectrum from the coherence between the seemingly disparate laws of "living" and "dead" chemistries to the formulation of the modern germ theory of disease.

From 1844 until 1854 Pasteur conducted an expanding series of experiments investigating the relationship between molecular forms — complex "twistings," deformations, and foldings in space — and their different properties. His discussion of the geometry of chemical transformations took chemistry decisively beyond the fixed atomism of John Dalton.**



V.I. Vernadski (1863-1945) was the intellectual father and scientific organizer of modern Soviet physics. He adopted a *fully nonentropic* notion of ever-increasing energy density as the invariant feature in the biosphere's evolution. His research approach was one of "biogeochemistry": mineralology, geology, and crystallography are subsumed by their participation in the "living" cycles and development of the biosphere as a whole. Vernadski emphasized that human creative mentation formed the highest part of the "energy continuum" in the universe and he used the concept *noosphere* to describe man's intellectual power that allows for his species' mastery of the material universe through scientific discovery, technological progress, and extended reproduction of the modern world economy.

Pasteur recognized that there was a crisis in the current notion of a fixed chemical species: "It will become necessary to pose the problem not only of the transformation of species but also of the creation of new species." His primary studies on molecular dissymmetry led to the startling discovery that forms the basis of his entire research and from which standpoint he called for advancing the frontier of theory *beyond* a "science of chemical mechanics," the chemistry

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different groups around the carbon atom are placed at the four corners of a tetrahedron. For every n dissymmetric carbon atoms present in a molecule then, there exist 2^n number of active forms. F.R. Japp in 1898 advanced the hypothesis that dissymmetric molecules do not arise from some sort of "primary synthesis" but can be the result only of activity from other prior-existing dissymmetric molecules.

Between the years 1904 and 1907, two principal features of the discussion came into experimental focus. W. Marcwald and A. McKenzie demonstrated that through the influence of an optically active molecule there exists the possibility of dissymmetric synthesis. A. Byk, on the other hand, reproposed that the primary operative force was not to be located in given molecules but in the global terms of the effect of the earth's magnetic field upon partially plane polarized light from the sky.

The paradoxical duality between these two viewpoints haunts subsequent thinking. Some scientists have argued that dissymmetry is a precondition for life, namely that it arose prior to biologic processes and in fact was a primary generative precondition for the creation of living molecular interactions; in the modern period, J.D. Bernal (1951) is the most well-known advocate of this view. Other scientists have chosen instead to feature the primary character of biologic processes, arguing that living processes have generated the dissymmetry phenomenon: S.W. Fox (1957) and A. and H. Amariglio (1971) have aligned themselves with this latter current.

From a purely methodological standpoint this duality on its own terms appears destined to degenerate into the trivial theoretical "chicken-or-egg" controversy. There is the unmistakable ring to the debate over whether it is DNA or protein that ought to be given evolutionary priority.

Mathematical physicists who understand the epistemological implications of Riemann and Cantor for the experimental data accumulated by the study of plasma domains, as well as scientists of Marxian political economy who have assimilated the basic conceptions of Lyndon LaRouche's *Dialectical Economics* (1975) will immediately recognize the classic features of the real problem underlying this seemingly irresolvable paradox. Wherever one tends to come across chicken-or-egg controversies in the interpretation of modern scientific data, one can be fairly certain that it is necessary to resituate the theoretical problem along lines of the advanced geometric dynamics associated with interactions between the totality (evolving manifold to qualitatively higher manifolds) and the particular (individual or finite number). Scientists who work on the significant sort of "borderline" phenomena between living and inorganic forms ought to be in the most advantageous positions, from their knowledge of experimental evidence, for relating empirical evidence to the specifications of the General Evolutionary Law of the universe.

It is exciting and lawful that in the twentieth century the work of Pasteur on dissymmetry gave birth both to the thesis of A.I. Oparin in *The Origin of Life* and, mediated through the Curies, to the advanced scientific notions associated with the school of V. Vernadski. Furthermore, since the 1920s there is a body of experimental concerns broadly associated with the origin of life thesis that represents — compared to the rest of Darwinian- and reductionist-permeated developments in the biomedical sciences — a healthy current of contributions from which to advance the understanding of living processes as a whole. Such positive features, generally speaking, are absolutely not to be confused with the laboratory attempts to recreate the origin of life under various combinations of primary conditions.

From this standpoint we will briefly reference what is only one of many intriguing experimental concerns that the tradition of Pasteur has led to in the twentieth century: the comparative studies, well known in specialist fields, of the similar yet differing qualitative distinctions associated with the cosmogony of Laplace and Lagrange.

This is usually misreported to be the exact opposite of Pasteur's intent. Pasteur draws from the dissymmetry experiments the notion that the products of vegetable and animal cellular activity are *not* distinguished from results that could occur *under special conditions* in the mineral world naturally or be achieved in the laboratory artificially by virtue of their material constituents or simple laws of interaction. As Pasteur wrote in 1853: "The barrier between mineral or artificial products and those formed under the influence of life, is a distinction of fact and not of absolute principle."

A few years after Pasteur's death his student Pierre Curie applied the concept of dissymmetry to broader physical phenomena which bore resemblance to unique characteristics of biologic systems. Curie suggested that the phenomena associated with structures exhibiting right-handedness (dextro-forms) and left-handedness (laevo-forms) were only one species of a broader class of effects, rather than the term dissymmetry. These structures could be more descriptively named "unique states of space" to emphasize their geometric foundations, Curie proposed.

Curie's student V.I. Vernadski later embraced the suggestion that the phenomena were broader than simple left and right antipodes. Vernadski wrote of different "states of cosmic space as the basic geometric substratum with all its material, temporal and energetic manifestations." He further specified that the geometry he had in mind would most naturally be created along the conceptual lines established by Bernhard Riemann's notion of a *n-fold extended manifold.* (Vernadski 1944)

The modern concept that applies to the observations developing from Pasteur, a notion already established in the scientific domain today, is *nonlinearity*.

In the next section I will develop the empirical material of Pasteur's *dissymmetry experiments and then explore how* far Pasteur himself was able to extend these insights to a wide range of scientific problems.

Pasteur: A Commitment to Progress

In a broader social sense, Pasteur embodies a sophisticated commitment to the notion of human progress through scientific development. From the early 1850s on, he was associated with programs to revive the tradition of the late eighteenth century Ecole Polytechnique that flourished when France was looked to as the pre-eminent nation of scientific achievement and technological innovation.

In 1854 Pasteur was appointed the founding dean of the Faculté des Sciences at Lille, in the midst of France's industrial brewery center. Under Pasteur the Lille project introduced unique conceptions of scientific pedagogy. The school program consciously recruited student cadre from the families of the industrial workforce and students were allowed to enter the laboratories to repeat the crucial experiments of the lessons. Pasteur also introduced the policy of taking physics and chemistry students on tours of French and Belgian factories, iron foundries, and steelworks.

The theme underlying the Lille project, a theme Pasteur was to strike often in the next four decades, was that the French nation could avert crisis and decay only by recovering its commitment to scientific development embodied in the establishment of the École Polytechnique in 1794 by the world's leading scientists. In his polemic Pasteur emphasized the decisive influence of *the American* Benjamin Franklin on founding the École.

At the turn of the twentieth century, when mathematician Felix Klein traveled to the great Chicago Exposition, he referred to the foundation of the École as the "decisive event" in initiating the nineteenth century's unprecedented advances in science. Klein isolated two attributes of the École's influence: the approach of combining theoretical research and active instruction and the publishing of lectures which served as the textbooks for European science instruction.

As I shall show, the principles embodied in this tradition are not at all unrelated to the overlooked importance of Pasteur's scientific contributions.

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between inorganic catalysts and enzymes. By no means do we intend to offer either an exhaustive or even a schematic representation of the enormous literature in the field. Rather, we hope to demonstrate the lawfulness of approaching such a question from the borderline experimental standpoint that is the essence of Pasteur's contribution. Between the years 1929 and 1933 four principal achievements occurred as a subdomain of the dissymmetry question:

(1) Kuhn, Braun, and Mitchell succeeded in a dissymmetric synthesis utilizing circularly polarized light;

(2) G. Bredig et. al. used catalysts to demonstrate that in living cells dissymmetric enzymes function like catalysts outside living forms, but far more efficiently;

(3) Karagunis and Drikos first succeeded in a dissymmetric synthesis of organic compounds;

(4) Schwab and Rduolf published results suggesting that dissymmetric crystals might be used as stereospecific catalysts.

In the 1950s and 1960s a great many scientific workers converged upon the investigation of phenomena that could be characterized as the relationship between the tradition of experiments in dissymmetry and the phenomena of *autocatalysis*. It is no longer seen as a startling occurrence that in living organisms one regularly encounters the formation and accumulation of only one particular antipode. In living beings, the insights first stated by Pasteur long ago have stood firm through a fantastic array of accumulated knowledge; in living beings amino acids and hence proteins almost all occur in the L-form, while biologic sugars are almost always in the *D-configuration*. A more detailed review on the relation between origin of life and dissymmetry studies in the twentieth century is available in *Chemical Evolution and the Origin of Life* edited by Buvet and Ponnamperuma, 1971. (See especially, "Origin and Development of Optical Activity of Bio-Organic Compounds on the Primordial Earth" by K. Harada and "Unsuccessful Attempts of Assymmetric Synthesis Under the Influence of Optically Active Quartz Crystals: Some Comments About the Possible Origin of the Dissymmetry of Life" by A. and H. Amariglio.)

Our motivation in this discussion is to emphasize a broader point bearing upon the necessary future course of events. Precisely the line of scientific development emanating from the origin of life circle has emerged in the past two decades as a leading cadre source for tackling the scientific tasks necessary for man's eventual colonization of outer space. Scientists in the United States, Soviet Union, and elsewhere from the tradition of studies associated with the origin of life thesis have emerged in the forefront of work associated with the creation of the newly termed domain of "exobiology." It is by no means accidental that a catalogue of the workers on the recent Viking Mission or similar Soviet endeavors, along with the *extant literature on similar subjects, is filled* with a high proportion of scientists who first were concerned with the body of literature developed on the origin of life question.

*For a full discussion of Cantor's concept of the transfinite as applied to a Riemannian continuum, see "The Concept of the Transfinite" (Parpart 1976).

**John Dalton (1766-1844) was the English physical chemist at the turn of the nineteenth century who developed a statement of atomic theory particularly oriented to chemical reactions. Dalton's theory, based upon atomic weights, indicated that chemical molecules were made up of atoms combined in ratios of small whole numbers. He wrongly used the formula HO to describe water, since he held that the most common compound of a set of given elements ought to have the simplest formula. Dalton (who was color blind) also carried out an extensive study of color blindness.

THE DISSYMMETRY EXPERIMENTS

Life is dominated by dissymmetric actions. I can even foresee that all living species are primordially, in their structure, in their external forms, functions of cosmic dissymmetry. *(1854)*

Pasteur's experiments on molecular dissymmetry imply a complete break with atomist theories of homogenous, flat molecular geometries in the small.* Even further, as Pasteur himself sought for some empirical reference points, his experiments imply that molecular geometries are not static and absolute but allow for transformations of internal molecular space and even the creation of new chemical species. These properties may be compared to the phenomena of differentiation and development generally associated with physiology. Proceeding from the totality of development on the biosphere as a whole to the particular, it would be on the right track to venture the formulation that *evolution* in the universe is mediated through the ordering of molecular physiology, namely that these transformations of molecular space have a direction to them.

In 1844, while a student in mathematics and physics, Pasteur accidentally came upon the problem that was to launch his investigations on dissymmetry for the next decade. The problem was embodied in a note by the physical chemist Eilhard Mitscherlich (1794-1863) which Pasteur recognized as appearing to completely upset every notion then standing in the concept of a chemical species.

The note in question concerned a startling conclusion drawn from a detailed study of two salt crystals of ammonia soda named tartrate and paratartrate. Tartrate had been studied since 1770 as a substance somehow critical to the process of grapes fermenting to wine; it was commonly found in wine barrels as thick, crusty material. Paratartrate, also known as racemic, was something of a mysterious curiosity among chemists from 1870 until 1853, when Pasteur succeeded in understanding its composition and easy production. The reason for the curiosity was that paratartrate had been observed once in the factory of an Alsatian chemical manufacturer. Chemists flocked there to study the new substance, but none succeeded in understanding its structure or could explain its presence.

Mitscherlich's famous note was on conclusions drawn from an exhaustive study of the two crystals: "The nature and number of atoms, their arrangement and their distances are the same. However, the tartrate rotates the plane of polarized light while the paratartrate is indifferent to it."

What troubled Pasteur was the seeming paradox in comparing Mitscherlich's conclusion to the then-taught definition of a chemical species as fixed in form and properties throughout members of the species. How could two substances, in all respects the same, differ with respect simply to the property of rotary power concerning plane polarized light?** From the outside both substances otherwise showed exactly the same physical and chemical data: identical crystaline form, specific gravity, index of refraction, melting and boiling points, solubilities, and so forth.

In conjuction with his teacher Jöns Jakob Berzelius,*** Mitscherlich himself had established the laws of isomorphism (1819) in which the "crystalline form is independent of the chemical nature." Pasteur's starting point was to establish that there was, in fact, a geometric relationship between the form of the molecules, their internal space, and their chemical properties. In 1848 Pasteur began an intense study of the crystalline structure of sodium ammonium tartrate, finding that the crystals were characterized by facets that annulled their symmetry. For the first time he established a definite relation between the form of the molecule and its rotary power on the plane of polarized light.

*The same dissymmetry of nature that Pasteur first observed in the optical activity of biological chemicals has been shown to play a vital role in fundamental physics and appears basic to the structure of the universe — as Pasteur hypothesized.

In the late 1950s, experiments in high-energy physics carried out by Wu, Yang, and Lee, demonstrated that matter exhibited "right-and-left handedness" in its interactions at high energy. In particular, it was found that in the decay of radioactive cobalt, as well as several other similar decays, the electrons were emitted with their spins preferentially aligned opposite to their direction of motion, or "left-handedly." In experiments where the electron's "antiparticle," the positron, was emitted (the positron is identical to the electron except that it has the opposite charge), the spin was aligned along the direction of motion, or "right-handedly."

This behavior is directly analogous to the ability of optically active molecules to rotate the plane of polarization of light in a clockwise or anti-clockwise direction, and it implies that matter and antimatter are related to each other geometrically in an analogous fashion to *oppositely* active molecules.

The resemblance becomes even more remarkable when one considers the dissymmetry between matter and antimatter. While these two forms of matter appear to be mirror images of one another, as do oppositely active molecules, the universe appears to consist overwhelmingly of ordinary matter; antimatter is exceedingly rare. Just as in living matter where one form of molecule predominates, rather than racemic mixtures — in the universe racemic mixtures of matter and antimatter are highly atypical.

There is evidence that this asymmetry of matter and antimatter is reflected in certain high-energy reactions. For example, the decay of the metastable particle known as the neutral Kaon preferentially produces a slight excess of electrons over positrons, indicating that the properties of matter and antimatter are not equally favorable to all interactions.

Recent experiments performed at the Argonne National Laboratory accelerator using spin-polarized beams of protons indicate that the effects of asymmetrical geometries continue to increase in importance with increasing energy of interaction. One set of experiments demonstrated that when the spins of the target and beam protons were both aligned perpendicular to the beam, the protons were scattered to the right about twice as frequently as to the left (relative to the direction of the beam).

Similarly, when the spins of the beam and target particles are aligned in opposite direction to each other, the scattering effects at high energies and near head-on collisions are dramatically less than in the parallel case.

These results are exceedingly difficult to explain from the standpoint of existing quantum theory: they strongly indicate that the asymmetrical geometries — such as helixes and vortices — which play such a crucial

The Critical Discovery

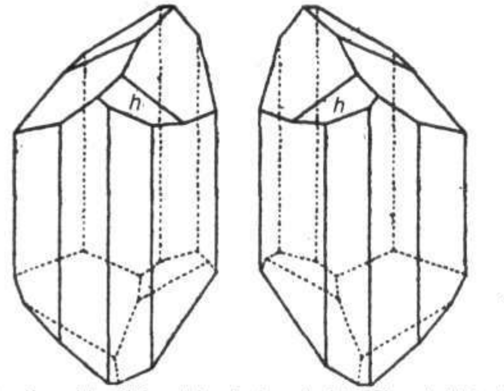
Pasteur observed that the crystalline forms of tartaric acid and all of its compounds have what he called dissymmetric form. By this he meant that their mirror images were not superposable upon the original; when the object rotated upon its axis to the right, its mirror image rotated to the left. Pasteur specifies other examples of dissymmetric forms, forms in fact that in the twentieth century have proven to be the critical structures of biological material: "a winding stair or helix, a screw, a hand, a branch with the leaves arranged spirally, and an irregular tetrahedron." Optically inactive compounds, he observed, however, did have superposable mirror images — for example, "a straight stair, a branch with leaves in a double row, and a cube." In the case of paratartaric or racemic acid, Pasteur discovered that the substance actually consisted of a neutral kind of balancing between some crystals of right tartrate and some of left.

Proceeding to separate right or dextro tartrate crystals by hand under the microscope from a paratartrate mass, Pasteur found that they rotated the plane of polarized light in the polariscope to the right. The crystals remaining with facets orienting to the left, had left rotary power. Thus, in 1853, he succeeded in transforming paratartaric or racemic acid into left-handed tartaric acid.

At this point in his research a critical fact confronted the observant Pasteur: this left-handed tartaric acid was identical in *all* respects with the acid found in the grape. Further, during the production of wine (fermentation) racemic or paratartaric acid is transformed into left-tartaric acid. He advanced the hypothesis that the living microorganism involved in fermentation must be able to consume only the right form of tartrate as nutrition in its metabolism and leaves behind, as it were, the left form. The microorganism selects one form and not the other and this selection process occurs based on its capacity to recognize one molecular form from another. This fact marked a critical experimental area of intersection for biology, physics, and chemistry.

Through a comprehensive experimental series of studies, Pasteur achieved the following pattern:

> All mineral products and all the numerous organic substances which one obtains artificially in the laboratory lack molecular dissymmetry and its correlative action on polarized light. Both of those properties, on the other



The "marking" facet is designated h. The right tartrate rotates the plane of polarized light to the right and is referred to as the dextro (d) form. The left tartrate rotates the plane of polarized light to the left and is referred to as the levo (l) form. The substance paratartrate or racemic (not shown) consists of equal mixtures of right tartrate and left tartrate. Crystals that can exist in either the dextro-or levo-form are known as *enantiomorphous*.
Source: Pasteur 1853

Above: Pasteur's original sketches of left-handed and right- handed tartrate crystals.

Below: Pasteur's wooden models of left-handed and right-handed tartrate crystals.

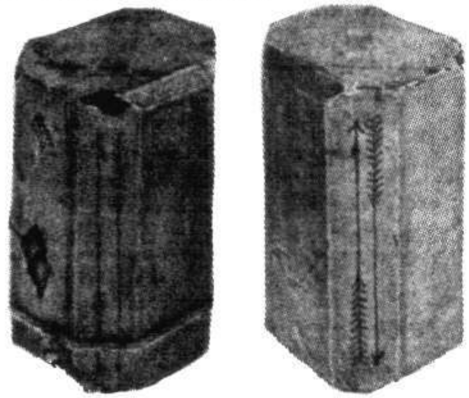


FIGURE 1

role in plasma physics phenomena as well as in the structure of biological molecules, are also central to processes occurring at very high energies and very small distances.

**In the year 1669 Erasmus Bartholinus discovered the phenomenon of *double refraction*, where a crystal oriented in a proper fashion divides a single ray of light into two. In 1677 Christian Huygens explained that each of the rays vibrated in a single plane and that the two planes were perpendicular to one another. Numerous scientists were fascinated with the implications including Johann Wolfgang Goethe (See the *Theory of Colors*).

In 1808 Etienne Louis Malus discovered the phenomena of polarization as a byproduct of researches on the double refraction properties of Iceland spar (calcite, a crystalline calcium carbonate). Malus looked from his room one day through the crystal at the brilliant sunset reflections coming off the windows of the Luxembourg Palace. Rotating the crystal slowly on an axis, he observed periodic variations in light intensity and certain positions of no light at all. In 1811 Malus's student Dominique-François Arago discovered that a specially cut quartz plate caused the rotation of the plane of polarization of plane polarized light. When the quartz is placed between perpendicularly crossed Nicol prisms, light passes through the second prism, whereas no light passes through simply crossed Nicols. Optical activity here refers to the ability to rotate the plane of polarized light. René Just Haüy had discovered two kinds of quartz which differed only in the location of two facets that caused the crystals to be nonidentical mirror images, termed *enantiomorphs* (from the Greek *enantios*, opposite and *morph*, form).

In 1815 Malus's student Biot found that plates of the same thickness from two different kinds of quartz rotated plane polarized light the same amount but in opposite directions. In a series of experiments from 1815 to 1835, Biot established that certain quartz crystals deflect the plane of polarized light to the right, others to the left. He noted theat certain natural organic material — for example, the solutions of sugar or of tartaric acid (α,β-dihydroxysuccinic acid or HOOCCHOHCHOHCOOH) have right rotary power; they are dextrorotatory. Other substances, such as turpentine and quinine, have left rotary power; they are levorotatory.

These findings were the immediate historic backdrop for the development of Pasteur's work.

***Jons Jakob Berzelius (1779-1848) was a Stockholm professor of chemistry who is credited with discovery of the elements silicon, thorium, and selenium. He developed the current system of element symbols, was an early leader in the determination of various atomic weights, and proposed an electrochemical theory of compound formation and stability based on the attraction between opposite electrical charges. His articles, texts, and reviews had a widespread influence on the European scientific community.

hand, are inherent in a great number of *natural* organic substances and an even more considerable number of substances related to physiology: that is, cellulose, sugars, albumin, fibrin, caseine, certain vegetable acids, etc. (1860).

What distinguishes Pasteur's work absolutely from the reductionist dogmas that currently pervade molecular biology was the way in which he sought to understand the indicated pattern:

> We discover that the natural products elaborated under the influence of vegetable life are, as a rule, dissymmetric. This is contrary to what we find in the case of artificial and mineral products. *This disposition of the elementary particles is* not *a condition of the existence of the molecule — that the twisted organic group can be untwisted and so assume the ordinary character of artificial and mineral substances.* Conversely, it seems to me logical to regard the latter as capable of exhibiting a dissymmetric arrangement of their atoms after the manner of the natural product. The conditions for their production have still to be discovered. (emphasis added) 1860

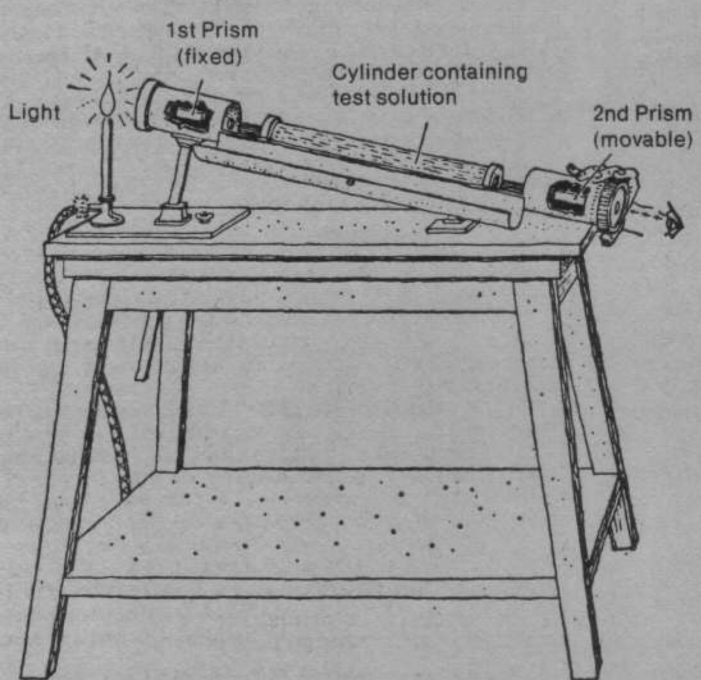
This marks the qualitative aspect of Pasteur's work. Against tremendous public and peer vilification he advanced the concept that what he termed a "living, well-ordered ferment" — like all living beings — tends to take the carbon and other elements necessary for its nutrition from right forms in preference to that from left forms. This could be explained only by the fact that the principal constituents of the living cell in turn were oppositely dissymmetric in form.

Pasteur established the thesis that

(1) molecular dissymmetry was correlative to living processes that gave them the capacity for higher grades of organization.

(2) this quality of living forms was not an epiphenomenon intrinsic to specific molecules as things-in-themselves,

(3) the dissymmetric forms encountered in living systems were somehow an attribute of that system's capacity to order itself on a higher level — that is to evolve, and



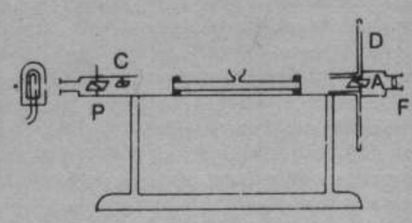


FIGURE 2a

Cross-section of a polarimeter

The polarimeter or polariscope is the optical instrument used to measure a substance's power of rotation of plane polarized light.

Source: Noller (1962)

Source: Grant (1959)

FIGURE 2b

Representation of the polarimeter constructed by Pasteur

A fixed Nicol prism, P, is known as the polarizer. Today, a monochromatic light source is used. The second Nicol prism, A, is also known as the analyzer, which in turn is attached to a special disc, D, graduated in degrees and fractions of a degree. Both A and D can be rotated. The sample for assay is placed in the tube which has clear glass ends. Usually a third small Nicol prism is located at C and rotated through a small angle in order to divide the viewed field into halves of unequal brightness. The eye piece for focus is at F. The zero point is when the two fields are at equal intensity after they have been rotated. Then a substance is introduce into the assay tube, placed in the path of light and the two fields of light become unequally bright. Rotation of D and A through a certain angle to the left or right brings the two fields to equal intensity of brightness. The number of degrees through which the analyzer is rotated measures the direction (right or left) and activity of the sample.

(4) this process was identical with the laws of the universe as a whole.

Pasteur wrote in 1874:

> What is the nature of these dissymmetrical actions? I myself think that they are of the order of the cosmos. The universe is a dissymmetrical totality, and I am inclined to think that life, such as it is manifested to us, is a function of the dissymmetry of the universe or the consequences which it produces.

Pasteur Maligned

With this thesis in mind, Pasteur pursued his researches yet further in directions that caused his fellow scientists to become hysterical. The common gossip in French chemistry and physics circles was that the promising young Pasteur had gone "over the deep end." Slandered as a mystic, Pasteur became the object of efforts by leading scientists to "turn him" from his course. The Academy of Science in 1857 refused to elect him despite his acknowledged discoveries.*

Pasteur had begun an array of experiments to subject living phenomena — plants, fermentations, and so forth — to various combinations of fundamental forces. His idea was that the dissymmetrical forces of the universe had to result from the mutual interaction between heat, light, magnetism, and electricity. He launched a path in experiment which is not at all distant from the pathway in theory which Riemann was considering at that time.** Pasteur constructed mirror machines, giant clockworks, powerful magnets, and electrical apparatuses. With variable light properties he combined these effects upon living processes to observe unique effects. A notebook entry from the 1870s, when he again picked up these experiments reads: "I want to be able by experiment to grasp a few indications as to the nature of this great cosmic dissymmetrical influence. It must, it may be electricity, magnetism..."

People thought he had gone mad. Professor Jean Baptiste Biot (leading experimenter on polarization and Pasteur's direct scientific mentor) wrote him with pleadings to "turn you from the attempts you wish to make on the influence of magnetism on vegetation.... To begin with, you will spend a great deal on the purchase of instruments with the use of which you are not familiar, and of which the success is very doubtful. They will take you away from the fruitful course of experimental researches which you have followed hitherto, where there is yet so much for you to do, and will lead you from the certain to the uncertain."

In the immediate aftermath of the failure of the 1848 Revolution in France, the forces opposed to scientific progress relentlessly harassed Pasteur and severed his funding. The same bankers who fought to maintain their looting rights over the working class tried to squelch any discoveries going beyond "mainline" experimentation of existing frontiers into the domain of the uncertain. Pasteur himself held on in Paris, quietly continuing his studies. "I am still hoping" despite no experimental success all year, he wrote in his notebook in December 1853. He held on for much of the year thereafter, too.

In the beginning of December 1854, Pasteur left Paris for Lille, the then center of France's industrial interests, particularly brewing, to found a unique institute for science funded by regional industrial interests. Pasteur was named dean and professor at the Lille Faculté des Sciences where he instituted revolutionary concepts of pedagogy.

Pasteur's speech December 7, 1854 to the combined audience of scientists, Lille area industrialists, members of the region's workforce, and students struck themes of future tasks that mobilized the spirit and morale that after 1848 had been atomized and crushed in many more souls than that of Pasteur.***

> Where in your families will you find a young man whose curiosity and interest will not immediately be awakend when you put into his hands a potato, when with that potato he may produce sugar, with that sugar alcohol, and with that alcohol ether and vinegar? Where is he that will not be happy to tell his family in the evening that he has just been working out an electric telegraph? And, gentlemen, to be convinced of this, such studies are seldom if ever forgotten. It is somewhat as if geography were to be taught by traveling; such geography is remembered because one has seen the places. In the same way your sons will not forget what the air we breathe contains when they have once analyzed it, when in their hands, and under their eyes the admirable properties of its elements have been resolved....
>
> Without theory, practice is but routine born of habit. Theory alone can bring forth and develop the spirit of invention. It is to you especially that it will belong not to share the opinion of those minds who disdain everything in science that has not an immediate application. You know Franklin's charming saying? He was witnessing the first demonstration of a purely scientific discovery, and people around him said:
>
> "But what is the use of it?" Franklin answered them: "What is the use of a new-born child?" Yes, gentlemen what is the use of a new-born child? And yet, perhaps, at that tender age, germs already existed in you of the talents which distinguish you! In your baby boys, fragile beings as they are, there are incipient magistrates, scientists, heroes as valiant as those who are now covering themselves with glory under the walls of Sebastopol. And thus, gentlemen, a theoretical discovery has only the merit of its existence: it awakens hope, and that is all. But let it be cultivated, let it grow, and you will see what it will become.
>
> Do you know when it first saw the light, this electric telegraph, one of the most marvelous applications of modern science? It was in that memorable year, 1822: Oersted, a Danish physicist, held in his hands a piece of copper wire, joined by its extremities to the two poles of a Volta pile. On his table was a magnetized needle on its pivot, and he suddenly saw (by chance you will say, but chance only favors the mind which is prepared) the needle move and take up a position quite different from the one assigned to it by terrestrial magnetism. A wire carrying an electric current deviates a magnetized needle from its

*In 1857 the Académie des Sciences rejected Pasteur despite the fact that he had already received international recognition for his groundbreaking studies in molecular dissymmetry. It was not until the third election vote on his membership, in December 1862, that Pasteur was elected to the Académie. Even then he received only 36 votes out of 60.

**See Riemann's "New Mathematical Principles of Natural Philosophy," 1853, in *The Campaigner* 9 (January-February 1976).

***The existence of a Lille industrial faction, committed to scientific development and the application of new technologies to production, raises some extremely important questions. The obvious indication is that, despite widespread historical accounts to the contrary, the anti-Rothschild forces in France were by no means politically dead in the aftermath of the 1848 Revolution. It is interesting in this context to consider with what determined swiftness Karl Marx was forced out of France and into London immediately after he developed his groundbreaking epistemological studies and program in France during the 1840s.

position. That, gentlemen, was the birth of the modern telegraph. Franklin's interlocutor might well have said when the needle moved: "But what is the use of that" And yet that discovery was barely twenty years old when it produced by its application the almost supernatural effects of the electric telegraph!

The Spectrum of Pasteur's Research

Pasteur on many occasions located the scientific tradition from whence he came — both in specific research and in general scientific spirit — by saying he was "the child of the great Ecole Polytechnique of the late eighteenth century." The Ecole Polytechnique was established in 1794 as the institutionalization of Benjamin Franklin's scientific cadre network in France after the brutal assassination of chemist Lavoisier.*

The Ecole represented the greatest concentration of leading scientists then in the world. These men were organized around a political commitment to the development of scientific theory as the means to utilize technology for achieving material progress: Gaspard Monge and Lazare Carnot the mathematicians; Abbe Huay, physicist of crystals; the chemist Claude Louis Berthollet; Antoine Francois Fourcroy, Jean-Antoine Chaptal, Guyton de Morveau; and, of course, Joseph Lagrange and Pierre Laplace.

In 1865 Pasteur wrote the frontispiece for the first official publication of Lavoisier's collected works, a piece in which he highlighted the necessity for France to reacquire the scientific commitment and spirit of the age of Lavoisier. Pasteur attributes to Lavoisier the first establishment of a system of "chemical mechanics," which was necessary for

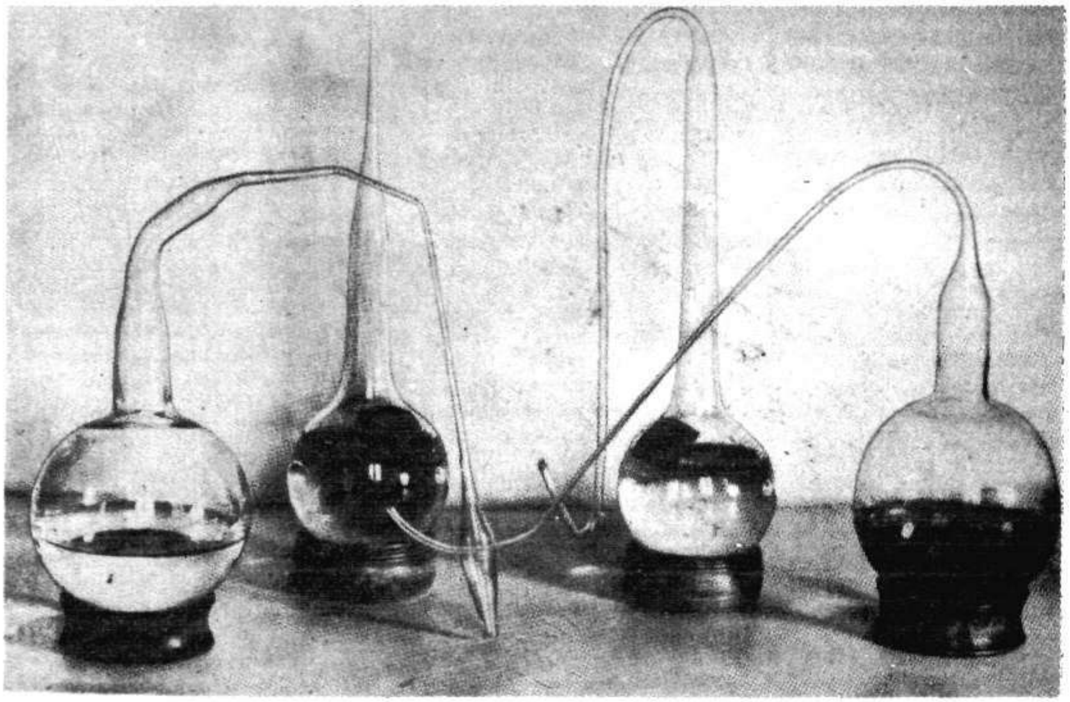


FIGURE 3

The glass apparatus used by Pasteur in his experiments on "spontaneous generation"

These experiments were the bridge from Pasteur's earlier work on molecular dissymmetry and fermentation to the development of the germ theory of disease.

Pasteur first demonstrated that air contained microorganisms in abundance. Air was drawn through a tube plugged with gun cotton; after 24 hours the cotton plug was dissolved in a mixture of ether and alcohol. The solid particles that settled were viewed under the microscope to reveal thousands of microorganisms. Thus Pasteur proved the presence of large numbers of organisms in the atmosphere, that appeared to be the same as known microorganisms and germs.

Second, Pasteur demonstrated that the germs floating in the air may be the source of infection. Modifying the technique of Schwann, he sterilized solutions in sealed flasks by heating them. In all these experiments the solutions were unspoiled and without microorganisms; if the flask was broken, however, the solution inside would quickly regrow bacteria and other microorganisms.

In response to objections from critics that his heating procedure destroyed the "life principle" in the air, Pasteur used the swan-necked flasks above. Untreated air entered the flask but dust particles were trapped in the S-tube before they could fall into the previously sterilized solution. As long as the swan-necks were unbroken, the solution in the flask remained uncontaminated. However, when the flask's neck was broken at the top before the curve began, the flask quickly became contaminated with microorganisms again. (Flask with broken neck is second from left)

These experiments gave birth to the science of bacteriology that underlies the modern germ theory of disease. Neither *vitalist* nor *deus ex machina* theories to explain the origin of living forms were tenable after Pasteur's experiments. As noted: "By his experiments Pasteur demonstrated beyond peradventure of doubt the impossibility of autogeneration of life in the sense as it was imagined by his predecessors. He showed that living organisms cannot be formed suddenly before our eys from formless solutions and infusions. A careful survey of the experimental evidence reveals, however, that it tells nothing about the impossibility of generation of life at some other epoch or under some other conditions. Incidentally, Pasteur himself, with his usual reserve, placed such an interpretation on his own experiments." (Oparin 1923) the science to begin. At the end of the eighteenth century Lavoisier had cleared away the obstacles for the study of such processes as combustion and fermentation by disproving the then-dominant phlogiston theory. Phlogiston was a mental artifact, a mysterious substance, supposedly contained in matter, that burned in air.

The discovery of oxygen and thereby an accurate theory of combustion led Lavoisier to conclude that all living things need oxygen for the breakdown of sugars into carbon dioxide and water for their nutrition. From the time of Lavoisier's publication of the *Traite Elementaire de Chimie* until Pasteur was urged to study the fermentation process by the Lille brewery industrialists years later, there was a complete shift in emphasis on the problem.

When Pasteur began his studies in 1854 the hegemonic view was that the breakdown of sugar into alcohol and carbon dioxide (fermentation) represented the general tendency in all organic material toward decomposition and putrefaction. Pasteur's experiments decisively altered the general tendency: "Fermentation is correlative with life, with the organization of globules, not with the death or putrefaction of those globules." (1858)

By stressing the continuous direction of living organisms toward higher orders of interaction and development, Pasteur opened the door for man's successful intervention into the "quality control" aspects of numerous industrial processes. Furthermore, he outlined the path for later contributions in the control of infectious disease — the abnormal condition of the general tendency.

While at Lille, Pasteur demonstrated that the fermentation process when milk sours (the production of lactic acid) is the result of a specific microorganism whose mode of metabolism depends upon a very selective environment and nutrition (1858). Through deliberate control of the parasite's environment and nutrients, Pasteur showed that men could consciously reorder the seemingly unstoppable natural tendency toward putrefaction. As is commonly known, Pasteur carried the same principles through for the understanding of the manufacture of wine (1863) and beer (1871-77).

Generally overlooked, however, is Pasteur's conception of the implications of his work on the idea of the evolution of the biosphere as a whole. First, Pasteur demonstrated that the fermentation process could be described as an interrelated complex that exhibited the character of his previously discovered notion of a cosmic force — molecular dissymetry. The primitive microorganism involved in one or another mode of fermentation orients and controls, as it were, its metabolic process through the selection of one molecular form of nutrient in preference to others. In wine manufacture, for example, the microorganism feeds more easily upon the right-handed form of grape acid (right tartaric) than on the left-handed form.

Thus, through careful observation and control of the geometric manifestations of the nutrient media, Pasteur was able to develop a practical assay method for following the development of the fermentation. The sugar-alcohol ratios could be controlled through scientific means instead of the current monkish rites. Fermentation could be described as a primitive or lower-order physiological process capable of being controlled by the human species.

Implications for the Biosphere

From this standpoint then Pasteur developed the insight, later understood most notably by Oparin and Vernadski, that a proper evolutionary principle ought to be applied to the biosphere as a whole. Pasteur's research led him to the discovery of primitive *anaerobic* microorganisms (metabolizing without need of oxygen) in butyric fermentation. In a series of experiments he then uncovered a special regime in the fermentation process in which microorganisms undergo a transformation from the aerobic to an anaerobic condition, a transformation that corresponds to transformations in the form of the microorganism from a more complex to a less complex physiology. Sugar is transformed into alcohol during the more primitive condition.

Pasteur formulated this insight into the principle, "Fermentation is life without air."

Most notably Oparin and Vernadski**, but others as well, later made explicit the suggestion that fermentation represents a condition of the biosphere as a whole at some time prior to what is referred to as the photosynthetic revolution. In order to indicate the dimensions of expansion embodied in the negentropic development of a world manifold characterized by fermentation processes of life to the higher order characterized by photosynthetic-respiration processes, one must isolate an appropriate invariant between the two totalities. As a first approximation, the notion of the energy throughput of the biosphere as a whole in its conversion of energy into biomass reveals a 24-fold increase. The maximum energy release in fermentation is 28 kilocalories per mole of substance, compared with 674 kilocalories per mole of substance in photosynthetic-respiration metabolism.

We can put Pasteur's insight into the most advanced scientific terms: The characteristic feature of the biosphere as a whole, in distinct comparison to what we know of the rest of the universe, is the capture of solar energy that is converted into biological material (biomass) through the mediation of inorganic material and biological waste material. Living process is not matter as such but energy.

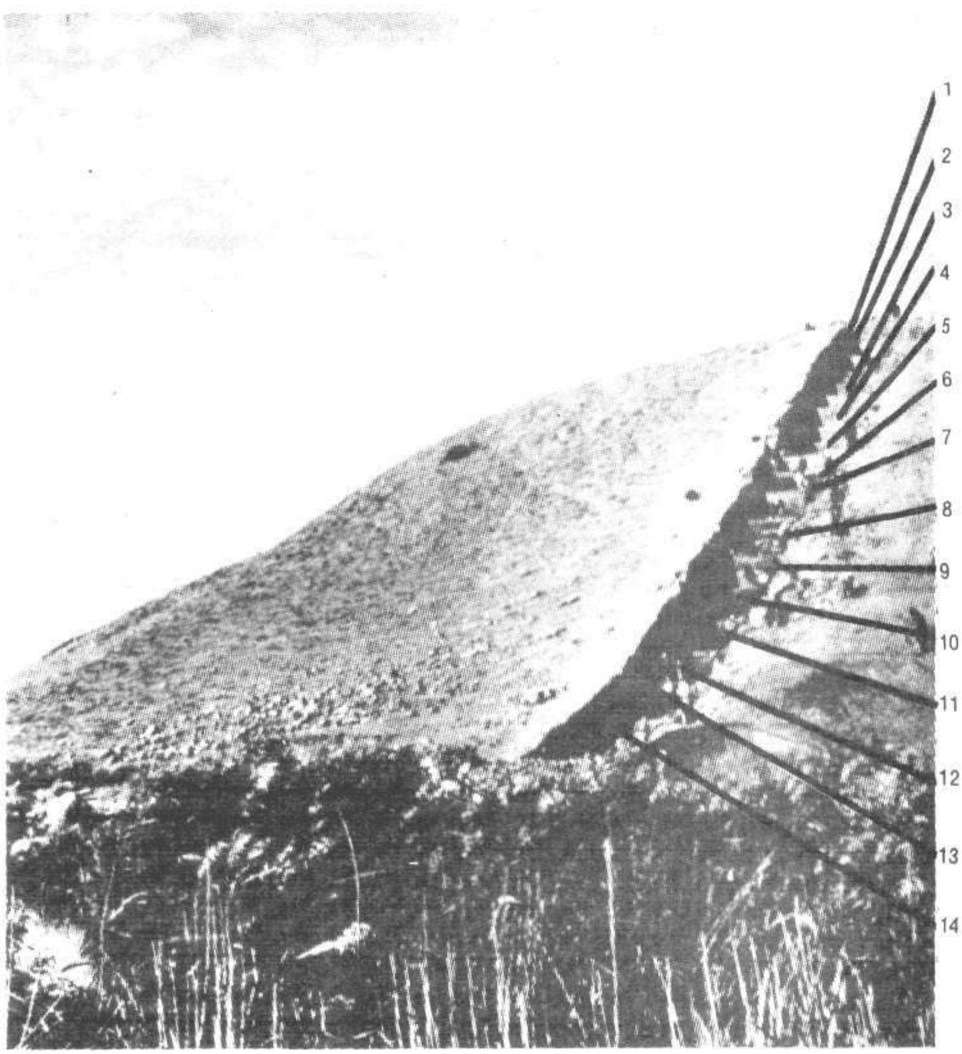
Of the total energy captured as added biomass, one part is consumed in maintaining the inorganic preconditions of life, another is consumed in maintaining the biomass of existing species, and a third, or surplus, is available as free energy. It is the last group that constitutes the margin of expansion into new modes.

The negentropic evolution of the biosphere prior to the existence of man, is coherent with the ideas embodied in the work of Riemann and Cantor: There is a transfinite quality of the ordering of the nested manifolds corresponding to the development of human species existence.

To locate the scientific principles involved in this transfinite, we can pedagogically extend familiar phenomena

*Antoine Lavoisier was executed May 8, 1794, as a result of the machinations of Jean Paul Marat and other British agents. Lavoisier, the principal collaborator of Benjamin Franklin in France, was a member of the Farmers General founded by Colbert. In 1778 he began a series of experiments to increase agricultural yield by scientific means. As secretary of the Society of Agriculture he most enraged the British monetarists by publishing a Franklinite agricultural program for France. Lavoisier argued in 1790 that debt, inflation, and taxes were looting the surplus from agriculture so that it could not be reinvested to expand agricultural productivity by industrial and scientific development. The immediate reason for his assassination was Lavoisier's issuance of a Plan for Public Education (1793) that designed a system of broad scientific education for the population along with the creation of a national central institute of leading scientists. Months later, Marat had him beheaded.

**Vladimir I. Vernadski (1863-1945) and his more famous Soviet scientific colleague A.I. Oparin were the subject of a study by the author entitled "The Self-Development of the Biosphere," published in *The Campaigner* 8 (January-February 1975).



from the sciences of archeology and anthropology to satisfy the conditions of a Riemannian "crucial experiment." The problem under consideration, it should be noted, is associated with the evolutionary laws that result from the ordering of human progress, along the methodological track described by G. W. Hegel in *The Phenomenology of Mind* and *The Philosophy of History*.

The record of human species civilization in ancient Mesopotamia is demonstrated by the existence of "tells," mounds rising 60 feet or more above the alluvial plain between the Tigris and Euphrates Rivers. The "tell," each of which stretches varying distances down into the earth, is the site of man's successive social development — temples, houses, tools, and kitchenware layered over the centuries one settlement on top of the other — down through man's past to the virgin soil of an ancient marsh newly emerged from the Persian Gulf at the beginning of human Neolithic life.

For pedagogic purposes, imagine extending the tell backwards toward the remote early Pleistocene when man's social existence was barely distinguished from that of other higher primates and the human species' population potential was of the order of a million or so. Then, mentally extend the tell up to the present population approaching four billion. The current potentiality of human culture based on the development of fusion power is for a population in the order of ten billion, even before man extends his domain outward into space. The transfinite quality of human species existence now stands properly in focus as the characteristic tendency for the realization of human creativity in scientific development.

Extended Reproduction

At moments of profound crisis regarding existing resources and limits of energy capture, man has applied his creative powers to science. Through technological advances we are able to alter and generate qualitatively higher orders of the production process. The concept properly embodying this transfinite aspect of human social development in a conscious and deliberate fashion is that of the Marxian notion of *extended reproduction*. Marx was well aware of the broader application of this concept to natural sciences: In 1854 he wrote in *The German Ideology*:

> The first premise of all human history is, of course, the existence of living human individuals. Thus,

1 AD 600-300 The level of an early Christian church. On a nearby site are even later Byzantine ruins and bronze crosses of the priests.

2 AD 300-64 BC A village partly contemporary with early Christian missionary activity in Antioch.

3 circa 64-500 BC An occupation of the period of the Persian Empire and of the Greek empires that followed the conquests of Alexander the Great.

4 circa 500-1000 BC Layers of the Syrian Hittite kingdom, contemporary with the later Assyrian Empire and the Babylonian Nebuchadnezzar.

5 circa 1000-1200 BC Ceramic traces of the "peoples of the sea," some of whom are known as the Philistines, others as the Archaeans who sacked Troy.

6 circa 1200-1600 BC A period rich in imported pottery of Cypriote and Aegean type.

7 circa 1600-1900 BC The beginning of marked technological advances in the second millennium BC.

8 circa 1900-2000 BC A period of transition, probably brief, during which distinct types of pottery were manufactured.

9 circa 2000-2300 BC A time of brilliant work in metal pottery.

10 circa 2300-2600 BC A period rich in connections with the south and east.

11 circa 2600-3000 BC A range marked by a fine red-and-black pottery series, excellent metalwork, and by cylinder seals of the Mesopotamian type.

12 circa 3000-3500 BC A period of technological advancement at the end of which appear the earliest known castings of human figures in metal. Links to both Egypt and Mesopotamia.

13 circa 3500-3900 BC Levels yielding rather drab pottery but the earliest types of tectonically conceived metal tools.

gap

14 circa 5000-5500 BC (?) Traces of materials in the range of the earliest known villages of Syro-Cilicia. Hand-made polished pottery, simple tools in bone and flint.

Step trench at
Tell Jedeidah, Syria

Tell, an Arabic word meaning "high," is used to designate a mound that was occupied by a succession of cities or towns. After destruction by war or fire, a new city would be built on the ruins of the old and the mound grew successively higher. Tell Jedeidah shows a series of civilizations superimposed on one another, with 14 distinct levels of occupation identified from 5500 BC to AD 600.

Source: The Biblical World: A Dictionary of Biblical Archaeology (New York: Bonanza Books, 1966)

the first fact to be established is the physical organization of these individuals and their consequent relation to the rest of nature. Of course, we cannot here go either into the actual physical nature of man, or into the natural conditions in which man finds himself — geological, orohydrographical, climatic and so on. The writing of *history must always set out from these natural bases and* their modification in the course of history through the action of men.

The proper ordering of the history and self-development of the biosphere as a whole — its successive transformation from one mode to those of a qualitiative difference — can be successfully compared to the universal evolutionary principle of man's development. Under the enormous influence of the philosopher Spinoza, mediated through Goethe, there is a deep current of hylozoic monism in the material universe throughout the methodology of nineteenth century scientists. Using this approach to view the history of the biosphere as a whole, the qualitative transformations from one mode to another exhibit the transfinite characteristics of nested manifolds:

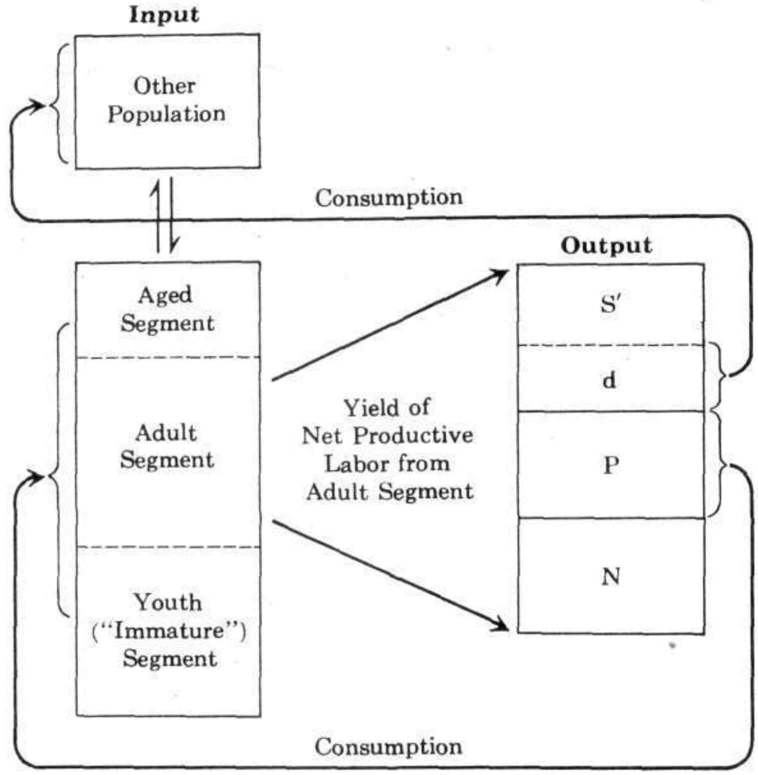
(1) the generation of a special nonlinear biologic geometry on earth evolves into a mode of "life" without air, a manifold of "life" under conditions prior to the current biospheric atmosphere until its expansion is strained by the limits of energy capture and net resources;

(2) the creation by this prior mode of life advancing beyond crisis through the invention of chlorophyll and the establishment of new preconditions for itself generating a higher manifold of life — the photosynthetic revolution;

(3) the generation by this mode of the capacity to evolve the characteristically higher-order feature of human life.

Man thus recapitulates the entire phylogeny of the universe. By the ability of the human species to consciously understand the universal laws characterizing this transfinite ordering process, man may utilize that concrete knowledge to alter the future course of the universe. The evolutionary principle here described subsumes the qualities of nonlinearity that are empirically seen in the coherence between the growing complexity of chemical and animal-plant species on the global life, as well as processes involving species interactions in the small.

The capacity of the universe to generate higher modes of living processes self-reflexively, processes of development that can then be replicated self-consciously by man, is the



A Refutation of Environmentalism

The actual historical relationship between man and nature can be defined concisely by the pedagogy developed by LaRouche in *Dialectical Economics*. LaRouche's general model of social reproduction yields the self-reflexive ratio

$$\frac{S'}{P + N}$$

where

P = material consumption required to reproduce the general productive sector of the population. In many societies P is only an ecological category and not a social one.

N = costs of maintaining nature and man-altered nature. Like P, N in many societies is not a social category.

d = consumption of sectors other than the general productive sector of the population.

S = social surplus.

S' = free energy of the society to maintain itself in a given mode (simple reproduction) or invest in expansion to a qualitatively new mode; defined as S — d.

The relationships among these categories can be heuristically modeled in the "input/output" diagram above:

The figure contains three principle elements:

(1) The large bar on the left represents the entire productive population with the society's own social (not biological) subcategories of immaturity and overage for productive work. The smaller bar, top left, represents the nonproductive, "other" population as a whole.

(2) The bar on the right signifies the totality of productive labor's "output."

(3) The arrows between the two bars signify the movement of persons, goods, and services.

A rise in the current value of the ratio

$$\frac{S - d}{P + N},$$

therefore, is a measure not only of development but also of existence. Since P and N must increase relative to their values for preceding states, from the standpoint of such states the impulse that gives rise to development or existence is *an exponential tendency for rise in the value of the given ratio.* Ralph Nader's "environmentalism," Herman Kahn's "ecosphere and biosphere people," and Barry Commoner's nonsense deny that there has been human social development by maintaining that man ought to bestialize himself to the level of brute equality with animals and other objects of nature. Their argument corresponds with increasing segment P while reducing N, d, and S' — thus forcing human existence to approach an animal state of reproduction: N = 0, d barely greater than 0, and S' extremely small or 0.

It is obvious that the condition of "zero growth" actually corresponds to a "negative growth" of human development rapidly converging upon the "extinction" of the human species. Conversely, as one approaches human development, N increases "at the expense of" P, and S' increases. Then S' increases "at the expense of" both P and N, but N continues to increase relative to P; that is, man produces the material preconditions to advance his productive existence to a higher level.

universal law of the cosmos for which Pasteur sought experimental data in his experiments of molecular dissymmetry.

The fact that this notion of an evolving universe is decisively beyond the realm of a Newtonian outlook bears special emphasis. At the close of the eighteenth century, Leibniz, and in particular, Kant, had advanced the worldview of Newton to its breaking point in a series of paradoxes. In this endeavor, Kant especially was constrained by the hegemonic authority of Lagrange and Laplace.

In the epistemological realm, both Leibniz and Kant utilized the phenomenon of left-handedness and right-handedness to pose an insoluble paradox for the Newtonian universe of absolute space and absolute time. Leibniz asserted that given states of space in which absolute metrics prevailed, left-hand and right-hand distinctions would be "indiscernible." In geometric terms, Leibniz described a condition in which congruent forms cannot be transformed one into the other; either the internal space is different or the forms are not congruent.

After Spinoza, Kant nurtures the simple Leibnizian paradox in the direction of a devastating antinomy for the Laplacean world view. In the *Prolegomena to Any Future Metaphysic* Kant generates the notion of a "geometry of the transcendental" in which "mental space renders possible the physical space." Therefore, either creative thinking is impossible or Newton's universe is only a flattened approximation to a reality of wondrous self-perfecting proportions. For pedagogic purposes, Kant concentrates on Leibniz's problem of a right hand in front of its mirror reflection:

> There are no internal differences which our understanding could determine by thinking alone. Yet the differences are internal as the senses teach, for, notwithstanding their complete equality and similarity, the left hand cannot be used for the other. What is the solution? These objects are not representations of things as they are in themselves, and as the pure understanding would cognize them, but sensuous intuitions, that is, appearances, the possibility of which rests upon the relation of certain things unknown in themselves to something else, *viz.*, to our sensibility, and the internal determination of every space is only possible through the whole....

Can Man Change the Laws of the Universe?

But can man change the laws of the universe as a whole?

The answer is decisively answered in the affirmative by Goethe. When man tries to study nature's laws in order to change them, he becomes aware of the reciprocal influence of a "twofold infinitude," writes Goethe in his introductory note to his series of essays entitled *Natural Science in General: Morphology in Particular* (1807). The "infinitude" in natural objects resides in "the diversity of life and growth and of vitally interlocking relationships." The other "infinitude" is in man himself — "the possibility of endless development through always keeping his mind receptive and disciplining it in new forms of assimilation and procedure."

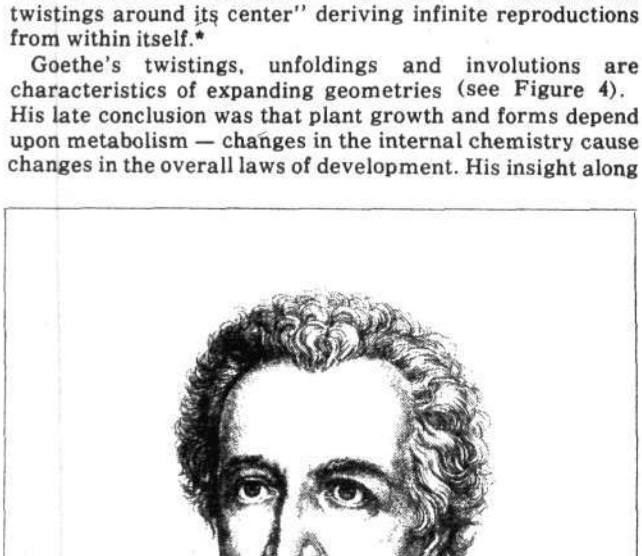
Echoing Spinoza on Descartes, Goethe admits that the latter infinitude is accessible to powers of expansion and "self-perfection" that in itself represents the highest lawful orderings in the universe.

There is an unmistakable parallel between Goethe's Leonardoesque concept of "morphology" and Pasteur's sketches of a developmental physiology of molecular interactions. Goethe's botanical studies constitute a polemic with Linnaeus's fixed, discrete species.

Goethe's stated aim was to develop a theory of "the formation and transformation" of living organisms. Certain dunderheads have attempted to pollute his project by coopting him as a forerunner to that anti-scientific Malthusian, Darwin. Goethe's objective, to the contrary, was to study and trace the patterns and sequences of forms in organisms. Vegetative growth, he believed, was a type of continuous reproduction that occurs successively and not by individual discrete developments. Contrary to Linnaeus, Goethe sought to classify the great mass of plants into a systemic ordering which indicated their "multiplicity in unity."

From this standpoint, Goethe derived a twofold law of evolution for the physiology of plants: the law of inner nature, whereby the plant has been constituted and the law of environment, whereby the plant has been modified. He characterized the process encompassing these laws as involving infinite unfoldings and involutions — a "thousandfold twistings around its center" deriving infinite reproductions from within itself.*

Goethe's twistings, unfoldings and involutions are characteristics of expanding geometries (see Figure 4). His late conclusion was that plant growth and forms depend upon metabolism — changes in the internal chemistry cause changes in the overall laws of development. His insight along



Johann Wolfgang von Goethe, 1749-1832

*Johann Wolfgang Goethe (1749-1832) is a towering figure in the development of the modern scientific outlook. Contrary to the prevalent reductionist view that human creativity is a mere predicate of the fixed and discrete empirical laws of the universe, Goethe represents the *humanist* tradition emanating from the early Italian Renaissance. The actual universal and primary character of *man as subject* to know, master, and change the laws of the universe for the benefit of his species' development pervades Goethe's literary and scientific works. As a byproduct of his studies on comparative and evolutionary anatomy, Goethe is credited with discovery of the intermaxillary bone in humans (1784). His studies of botany and physiology (1784—1831) decisively helped to shift the nature of the science from the earlier mode of Linnaeus. Goethe also explored an evolutionary approach to the development of the biosphere as a whole in his work on geology (1784). He also engaged in numerous experiments in attempting to advance the theory of light and color beyond Newton (1810).

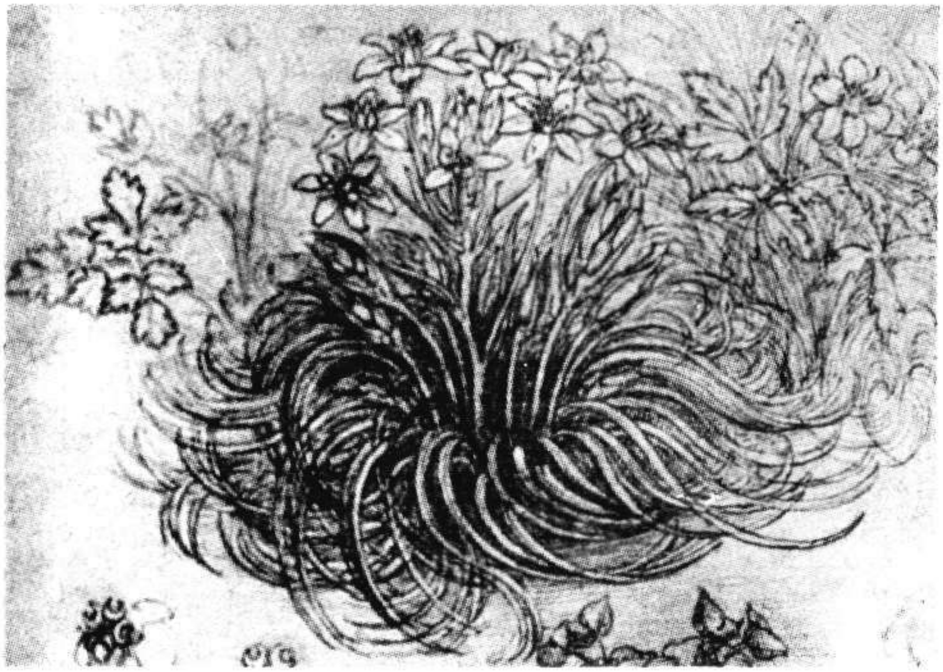


FIGURE 4

Wild Flowers by Leonardo da Vinci, 1513-14

Leonardo's famous drawing in pen and brown ink directly motivates Goethe's notion of morphology. Concentrating on the drawing one realizes both the principles whereby the plant grows as well as the individuality of the plant's form. Remarkably, while looking at the drawing, one is compelled to ponder the process of plant growth right before one's eyes.

these lines led Goethe to accurately characterize the problem with chemistry before Pasteur: Goethe wrote that the "chemist tends to annul form and structure to study properties and compositional relationship."

Pasteur's achievement was to empirically guide science beyond this system of classical "chemical mechanics."

Pasteur's Public Health Contribution

Returning to Pasteur's work itself, there is a development in his research from fermentation studies to investigation of what he termed "the borderlines between living and dead matter." In 1859 the director of the Museum of Natural History in Rouen, Professor F. Pouchet, published a treatise nearly 700 pages long that supposedly proved that spontaneous generation was possible.*

Pouchet's thesis, which Pasteur refuted in a widely known series of experiments (see Figure 3), was that life could arise in the presence of putrescible matter and a "life force." Furthermore, Puchet denied that microorganisms could be airborne and implicitly attacked the broader evolutionary principles embedded in Pasteur's work.

Although other sources identify the empirical accomplishments of Pasteur's research on spontaneous generation, two broader notions at the core of Pasteur's motivation are not generally given proper emphasis. Pasteur's notebooks and letters of the 1860-65 period make it clear that he was engrossed in the following questions:

Is there a way to reject the notion of spontaneous generation and what Pasteur termed "facile researches on primary causes" without discarding the notion of a hylozoic universe characterized by a "living" principle suggested in the tendency toward higher "organization of globules"?

How can the scientist establish the necessary bridge from man's ability to control disease conditions in such processes as fermentation in industrial production to a broader "public health" program that can control the spread of infectious diseases?

Pasteur's contributions toward the science of epidemiology and the notion of antiseptics underlying modern surgical techniques (1865-95) are enormous and well known. His principal studies develop from consideration of abnormal or "diseased" fermentation processes to studies on silkworm disease and cholera (1865), anthrax (1877), chicken cholera (1879), rabies (1880) and cattle pleuropneumonia (1882). In the study of these specific diseases Pasteur developed a general understanding of the dynamics of epidemic spread, prevention, and cure — in short, the modern theory of germs.

The global nature of the problem confronted Pasteur from his first work in 1865. The silkworm disease then ravaging French industry had shown its first symptoms in France in 1849 and had then traveled to Italy, Spain, Austria, and eventually China (1864) before reemerging in a devastating 1865 French outbreak. The cholera epidemic, which claimed 200 victims a day in Paris in October 1865, had spread from Egypt, to Marseilles, to Paris.

Pasteur's *Memoire on the Germ Theory* (1878) presents the conception that disease results from specific microorganisms that can be isolated and controlled. The phenomena of lower-order parasites running amok could be controlled by man's conscious raising of the level of health in the general population and man's environment. Man had the capacity to raise the threshold to what Pasteur termed "the resistance level to disease." "You see clearly, that something more than the microbe is needed to make us ill, since in this case (anthrax) we so often find the organism and so rarely the disease," Pasteur wrote.

In addition to natural immunity man can acquire immunity through vaccination against specific diseases and hence, contain and control illness. As a result of Pasteur's work, disease was removed from the realm of a spontaneously generating mystery outside man's control:

> Is it impermissible to believe that a day will come when easily applied *preventive measures* will arrest those scourges that suddenly desolate and terrify populations — such as the fearful disease (yellow fever) which has recently invaded Senegal and the valley of the Mississippi, or that other (bubonic plague), yet more terrible perhaps, that has ravaged the banks of the Volga.

Pasteur's Lesson for Today

Today, more than a century later, for no reason other than the irrational fears of the human species of decisively overthrowing the policies of monetarism, the world faces the threat of global ecological holocaust. In the process of achieving a fusion-based world economy the human species must pass from the current rearguard stance of fearfully defending itself from one specific disease attack after another — from humbly aspiring to a mere absence of sickness — to an era of actually creating self-expanding conditions for growth and development.

The basic feature of human historic development, as emphasized here, has not been characterized by the maintenance of an equilibrium or homeostatic state of health, but rather by the continuous production of a healthier and longer-lived human species.

There are three interrelated theoretical and practical aspects for superseding the acute ecological and epidemeological crisis for man and nature at the moment. All three demonstrate that processes in the universe — whether in the domain of human political economy, the biological sciences, plasma physics, agriculture, or an integrated chemistry of the inorganic and organic — are characterized by the sort of universal laws of development and pathology discussed above.

The primary, emergency consideration for all scientific advance in eradicating disease must necessarily be focused on the level of the biosphere as a whole. The health of man's biosphere is determined by qualitiative increases in the conversion of energy throughput into biomass; hence, fusion power.

The second area of focus is associated with human population policy as it determines the state of the overall ecology. Competent policies begin with a complete rejection of all Zero Population Growth, Malthusian-Darwinian models and all Schachtian *arbeitsdienst* programs.** Positively stated, human population policy is expressed by the Marxian notion of expanding *labor power*.

The third area — that of living processes within the individual human organism itself — will rely most greatly on recent advances in plasma physics for qualitative breakthroughs in understanding.

Pasteur's concept of the necessity for rising qualities of public health was highlighted by a sophisticated political campaign for scientific development, which he developed at the same time that he was engrossed in studies of infectious disease. The specific issue was the 1868 Budget of Public Instruction, dictated by the Rothschild bankers, which allocated no one *sou* for physical science research. Pasteur issued his own program entitled "Science's Budget," which appeared first in the departmental journal, *Revue des Cours Scientifiques*, and later as a mass-distribution special pamphlet since all official government and educational journals had balked at printing the piece. Pasteur embarked on a nationwide speaking tour urging the establishment of a special advanced university program dedicated to scientific development and upgrading higher education.

His program called for the Paris institute, modeled on the old Ecole Polytechnique, to become the centerpiece of a nationwide university network of regional scientific institutes patterned on his Lille Faculte des Sciences. In his science budget pamphlet he wrote:

> The boldest conceptions, the most legitimate speculations can be embodied only from the day they are consecrated by observation and experiment. Laboratories and discoveries are correlative terms; if you suppress laboratories, Physical Science will become stricken with barrenness and death; it will become mere powerless information instead of a science of progress and the future. Give it back its laboratories, and life, fecundity, and power will reappear. Away from their laboratories, physicists and chemists are but disarmed soldiers on a battlefield.

Pasteur's pamphlet directly addressed the common interest of the French industrialist and working class in advancing science:

> The deduction from these principles is evident: if the conquests useful to humanity touch your heart — if you remain confounded before the marvels of electric telegraphy, of anaesthesia, of the daguerreotype, and many other admirable discoveries — if you are jealous of the share your country may boast in these wonders — then, I implore you, take some interest in those sacred dwellings meaningfully described as *laboratories*. Ask that they may be multiplied and completed. They are the temples of the future, of riches and of comfort. *There humanity grows greater, better, stronger; there she can learn to read the works of nature, works of progress and universal harmony, while humanity's own works are too often those of barbarism, of fanaticism, and of destruction.* (emphasis added.)

Pasteur then wrote that France would head into a crisis unless the nation made a total commitment to scientific development. Three-and-a-half years later when that disaster had come in the form of the Prussian army crushing the Paris Commune, Pasteur wrote a piece entitled "Why France Found No Great Men in the Hours of Peril." He answered the question of his title with a polemic against what he termed France's "forgetfulness, disdain even for great intellectual men, especially in the realm of exact science."

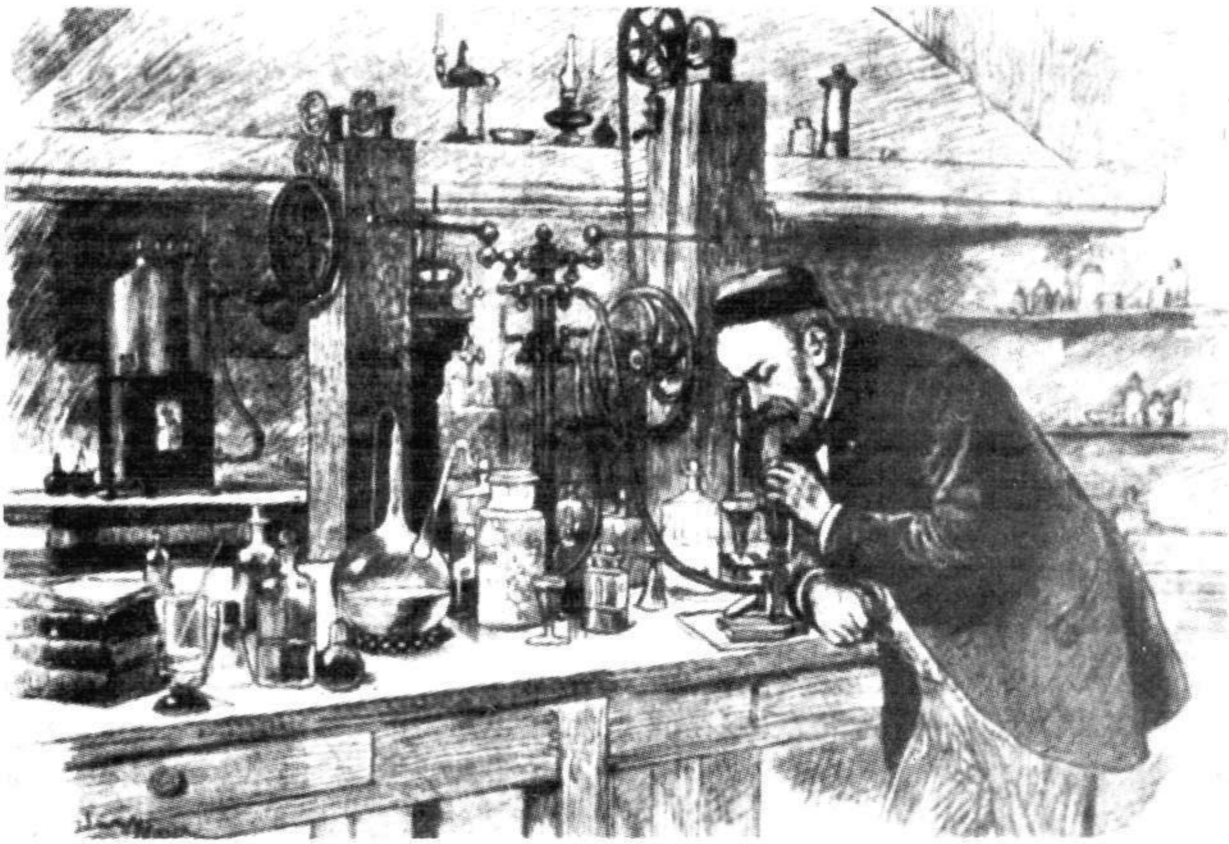
Pasteur contrasted the current crisis in France with that faced during 1792 when the nation "was able to face danger on all sides" because Lavoisier, Fourcroy, Morveau, Chaptal, Berthollet and others applied the advanced principles of scientific discovery to practical industrial and military tasks.

The tragic guillotining of Lavoisier as a result of Marat's incitements convinced Monge, Berthollet, and others, Pasteur wrote, that they must found an institution for scientific development — the Ecole Polytechnique — as a bridgehead for progress lest all scientists be arrested, tried, condemned, and executed. Pasteur then described how Napoleon coopted science for his military campaigns and broke up the Ecole; France fell from its superiority in science.

> A victim of her political instability, France has done nothing to keep up, to propagate, and to develop the progress of science in our country. She has merely obeyed a given impulse; she has lived on her past, thinking herself great by the scientific discoveries to which she owed her material prosperity, but not perceiving that she was imprudently allowing the sources of those discoveries to become dry....
>
> The cultivation of science in its highest expression is perhaps even more necessary to the moral condition than to the material prosperity of a nation. Great discoveries — the manifestations of though in Art, in Science, and in

*The history of the debate on spontaneous generation is easily accessible to readers through works by Oparin, Keosian, and others.

**For a full discussion of the mutually exclusive notions of *Schachtian economics*, on the one hand, and qualitatively expanding *labor power*, on the other, see *Dialectical Economics* (LaRouche 1975), "Rockefeller's Fascism With a Democratic Face" (LaRouche 1974); "The Italy Lectures" (LaRouche 1975); and "A Multi-Partisan Energy Policy" (LaRouche 1977).



Pasteur in his laboratory

Letters — in a word the disinterested exercise of the mind in every direction and the centers of instruction from which it radiates — introduce into the whole of Society that philosophical or scientific spirit, that spirit of discernment, that submits everything to severe reasoning, condemns ignorance, and scatters errors and prejudices. Great discoveries raise the intellectual level and moral sense, and through them the Divine idea itself is spread abroad and intensified.

Pasteur then reiterates his call for a national program of scientific development.

In 1876 Pasteur placed himself as a candiate for the French Senate to "represent in the Senate, Science in all its purity, dignity and independence." One of the outrageous ironies of history is that the 650 senatorial electors gave Pasteur only 62 votes — placing him fifth and last behind the monarchist candidate! The official explanation of the electors was that "science has its natural place at the Institute" and not in the parliament.

As a result of the immense public and industrial pressure that Pasteur mobilized during his campaign, three months after the election the minister of public instruction was forced to announce his endorsement of the program outlined in Pasteur's 1868 pamphlet that had become the basic political theme of Pasteur's senate campaign: providing the College de France with new laboratories, transferring and enlarging the Faculty of Medicine, developing a nationwide program for the physical sciences, and so forth.

At the close of his life, Pasteur established a scientific Institute named after him. The Pasteur Institute was funded by the extraordinary means of an international subscription drive so that science research, in his words, would not be shackled to the particular whims of a particular government. He raised 2,586,680 francs from industrialists, government officials, workers' organizations, and small individual contributions from around the world.

Pasteur's fundamental premise that the laws of evolution of living forms and the universe as a whole are "distinctions of fact and not of absolute principle" emanate directly from his political approach to the question of scientific development. If this is not to be misunderstood in a frivolous sense — running completely counter to Pasteur's own intent — biological scientists, plasma physicists, mathematicians, and broader sectors of the population must compare notes with utmost regard for the task orientations required by a fusion-powered world economy. If we are intent on getting there, Pasteur cannot be overlooked.

APPENDIX

Observations on Dissymmetrical Forces

Louis Pasteur

The following is a translation of Louis Pasteur's "Observations sur les Forces Dissymétriques, Comptes rendus de l'Académie des sciences, séance du 1 juin 1874."

The author was motivated to translate this article by the incredible paucity of Pasteur's early works in English. Pasteur's two longer essays on molecular dissymmetry, given as a famous lecture series in 1860, were printed in a miniscule English pamphlet by the Alembic Club of Scotland in 1897 and have never been reprinted. There exist in English a few extant excerpts from some of Pasteur's pieces, but the conceptual content is usually edited out.

The above selection was chosen because it touches upon the range of Pasteur's thinking in a highly concentrated form.

This is the first English translation of the selection.

I would like to see the products obtained by M. Cloez subjected to the action of polarized light, in comparison with similar products prepared with the aid of a steel magnet. However strange it may seem at first glance, these are the reasons for my wish.

All mineral products and all of the numerous organic substances which one obtains artificially in the laboratory lack molecular dissymmetry and the correlative action on polarized light. Both of these properties, on the other hand, are inherent in a great number of natural organic substances most important from the physiological standpoint: such as cellulose, sugars, albumin, fibrin, caseine, certain vegetal acids, etc.

Indeed, I have recognized that ordinary succinic acid, an (optically —WH) inactive body, in the hands of MM. Perkin and Duppa supplied some paratartrate acid resolvable into right tartaric acid and into left tartaric acid.

Subsequently M. Jungfleisch in a series of experiments accomplished with rare skill arrived at the same result after starting with the synthesis of succinic acid which M. Maxwell Simpson had successfully prepared from the elements carbon and hydrogen. Notwithstanding these last achievements, they do not alter the truth of the following statement: Up until the present no one has ever formed a simple (optically —WH) active body with inactive bodies. I am even inclined to believe that the number of *paratartrates* and *derived paratartrates* is considerable. The *paratartrates* are one of the forms of bodies which have a symmetrical plan and they originate under the influence of actions which have nothing dissymmetrical.

The opposition between the existence of chemical actions of symmetrical order and of dissymmetrical order was introduced into science the day when it was recognized that the physical and chemical properties of right and left tartaric acids (identical whenever inactive non-dissymmetrical bodies are set going in their presence) became, on the contrary, dissimilar when these acids are under the influence of active, dissymmetrical bodies. The role of molecular dissymmetry was also introduced as a factor to the phenomena of life, the day when it was verified that a living well-ordered ferment takes to fermenting right tartaric acid easily, while not to left tartaric acid.

Living beings take the carbon necessary to their nutrition from right tartaric acid in preference to carbon from left tartaric acid. Hence, since there is dissymmetry in the immediate natural laws — notably in those which can be considered as primary — namely, in the immediate constituent principles of living cells; since vegetables produce simple dissymmetrical substances to the exclusion of their inverses; since, in contrast to what is produced in our laboratory reactions, the vegetable kingdom does not form exclusively paratartrates or simple inactive suzstances; and since it probably forms these latter substances only through oxidations or secondary reducing actions similar to those of mineral chemistry, as natural oxalic acid or acetic acids show; I conclude that it is absolutely necessary that dissymmetrical actions preside during life over the elaboration of the true, immediate natural dissymmetrical principles.

What is the nature of these dissymmetrical actions? I myself think that they are of the order of the cosmos. The universe is a dissymmetrical totality, and I am convinced that life, such as it is manifested to us, is a function of the dissymmetry of the universe or the consequences which it produces. The universe is dissymmetrical, for if the totality of the bodies which comprise the solar system were to be placed before a mirror moving according to their own motion, then the image in the mirror would not be superposable to reality. The movement of solar light is dissymmetrical. A light ray never strikes in a straight line and at rest the leaf where vegetal life creates organic matter. Terrestrial magnetism, the opposition which exists between the north and south poles in a magnet, that offered us by the two electricities positive and negative, are only probably resultants from dissymmetrical actions and dissymmetrical movements.

From all of the preceding, I believe that it can be deduced that we will succeed in leaping over the barrier established between the mineral and organic kingdoms by our inability to produce dissymmetrical organic substances through our laboratory reactions only if we succeed in introducing into these researches influences of a dissymmetrical order. Success in this avenue will give access to a new world of substances, reactions and probably as well, to organic transformations. It is at that point, it seems to me, that we should locate the problem not only of the transformation of species but also of the creation of new species. Who could say what would become of plant and animal species if it were possible to replace cellulose, albumin, and their cognates in living cells by their inverses? The difficulty in resolving these problems should not prevent us from noting their existence. Since one succeeds in finding the inverse to right tartaric acid, surely one day we will succeed in possessing all the immediate inverse principles to those which now exist. When one wishes to go further in the physiological order, when one wishes to introduce these new immediate principles in living species through nutrition, the great difficulty — I fear — will be to win over the *becoming* characteristic of species, potentially contained in the germ of each of them, in which germ the dissymmetry of the immediate present principles will always be manifested.

Nonetheless, by every possible means, let us seek to provoke molecular dissymmetry from the manifestation of forces having a dissymmetrical action. Today, and in reference to the just completed discussion before the Academy on hydrogen carbides, it is enough for me to know that magnetism has mysterious properties of opposition and that Ampere was able to represent magnets as formed by electrical currents in solenoids. For this I believe myself justified in posing the following question: would not the magnet — penetrated with an unknown (force) which makes it a magnet and which, I imagine, is not superposable to its image — yield dissymmetric molecules at the critical moment of the mysterious combination of its carbon with hydrogen? I would go even further. I would like to compare the (various) carbides of hydrogen formed simultaneously and separately by submitting them to the attack of the two poles of a magnet, even though a magnet can be considered formed of an infinity of elementary "magnets," the resultant of which effects constitute the properties of natural or artificial magnets.

Our colleague M. Thenard and his son obtained some new as well as previously known substances in a series of original and profound researches with electrical fluxes. Wouldn't these substances tend to have molecular dissymmetry? There are numerous other circumstances where one can suspect the influence of *solenoid actions*, if I may say so. The ones I motivated are enough for you to understand what I mean. Engaged in more than enough work to absorb what I have left of activity and strength, I leave to the younger scholars of a new generation the preceding ideas with the hope that they will know how to bring them to fruition.

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* Denotes work on questions central to the methodology of the modern scientific outlook.

About the Authors

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Warren Hamerman is a member of the National Executive Committees of both the U.S. Labor Party and the National Caucus of Labor Committees. He has been a leading participant in the planning of international development programs and policy toward the realization of the new world economic order and the early attainment of a fusion-powered world economy. In late 1974, Hamerman was a member of the scientific task force that developed the groundbreaking conceptual model of the "ecological holocaust" now endangering man and his biosphere.

In the last three years, Hamerman has been a director of political and legal campaigns to eliminate the virus of Naderism, environmentalism, and zero-growth policies. Most recently, he has edited a Labor Party pamphlet ("Bust the Drug Ring in the White House") detailing the medical and social evidence against the dangerous drug proliferation policy of the Carter administration.

Hamerman has lectured extensively in the United States and Canada on science, political economy, philosophy, and international political affairs. His published articles include "The Self-Development of the Biosphere," "The British 'Holists': Imperialism's Jungle Rulers," "Frontiers of Biomedical Research: On the Offensive Against Disease," and "Rockefeller's Biochemical Warfare: The Creation of the LSD Culture."

Eric Lerner

Eric Lerner is a member of the Fusion Energy Foundation research and development staff. For the past five years, he has done groundbreaking work in the study of the self-development of the biosphere and he was a member of the 1974 scientific task force that developed the conceptual model of "ecological holocaust." Lerner has concentrated in particular on the integration of the physical and biological sciences into a single science of evolution.

His published works include many articles applying ecological theory to global economic planning, epidemiology, and climatology. Currently he is working on a computer simulation of weather phenomena and on the theory of self-ordering phenomena in high-energy physics.

Lerner received a BA in physics from Columbia University and did graduate work at the University of Maryland.

Dr. Richard Pollak

Dr. Richard Pollak is a member of the newly formed biological sciences section of the Fusion Energy Foundation. He is currently doing further research on the controversy of recombinant DNA as well as on other questions raised in the article published here.

Pollak holds a PhD from the University of Wisconsin where his thesis research concerned the patterns of macromolecular synthesis during cellular differentiation. He also did research at Columbia University Medical School on the mechanism of action of anti-cancer drugs.

Publications of Pollak's research have appeared in the journals *Cancer Research*, *Biochim*, *Biophysica Acta*, and *Experimental Cell Research*.

Ned Rosinsky, M.D.

Ned Rosinsky is a member of the research and development staff of the Fusion Energy Foundation and a practicing physician in New York.

In the past month, he has testified against marijuana decriminalization before the Maryland State Senate, and he has submitted extensive testimony to the Congressional Select Committee on Narcotics and Drug Abuse on the damaging medical and psychosocial effects of marijuana.

Rosinsky authored the Labor Party's Comprehensive National Health Service Act of 1976, and during the last three years he has written a series of articles for the Labor Party on how collapsing living standards, particularly diet, are related to the onset of epidemic disease in both the advanced sector and the Third World. Recently he has lectured on recent advances in the development of nonlinear concepts in such areas as neurophysiology and embryology.

Rosinsky is a graduate of the City College of New York and Wayne State Medical School.

Evolution As a Process of Self-Organization

Eric Lerner

The history of the evolution of the earth is the most dramatic empirical refutation of the commonly accepted axioms of the present-day physical and biological sciences. On the basis of the laws of thermodynamics, the earth should have evolved toward equilibrium and disorder — continents and mountains eroded beneath the level of universal oceans, climatic differences flattened out, energy flows reduced toward zero. Similarly, the laws of Darwinian evolution would dictate the development of the biosphere toward a steady-state balance of organisms perfectly adapted to their finite resources and the continual slowing of evolution to an eventual standstill.

The actual evolution of the earth proceeded in exactly the opposite direction — toward greater order and greater rates of development. Over hundreds of millions of years, mountain ranges and continents have arisen out of the primitive swamps and seas; the initially uniform climate has given way to our present arctic cold, tropical heat and rain; energy flows through the biosphere continually increased; and living organisms evolved with continuously *increasing* speed from a few primitive forms to the present vast quantity and diversity. The accelerating evolution of the earth was punctuated by periodic ecological revolutions, in which the entire mode of development, both geological and biological was suddenly transformed.

The gross contradiction between the current theoretical expectations and actuality is not surprising, since the theories held by present-day scientists locate the processes of progress, self-development, and self-ordering not as primary, but rather as anomalous. In contrast, the evolution of the earth provides an excellent example of the principles of the self-developing progress of the universe as a whole in that it demonstrates not merely a single process of self-organization, but an ordered sequence of such processes whose historically specific laws of development are themselves modified by the process of evolution.

FIGURE 1
The Phanerozoic Era

This diagram shows the major divisions and evolution of plant and animal groups (far left column): the average mid-latitude temperature (middle column); and the volume of the continents above sea level as a percentage of present volume (estimated on the basis of average elevation and land area).

Note simultaneous revolution and general trends toward cooling and greater land area.

Toward a New Science of Evolution

Just as the self-ordering phenomena in energy-dense plasma necessitate a fundamental reexamination of the traditional physics approach, what is necessary today is the refounding of the science of evolution, replacing Darwinian and reductionist ideas with the principles of self-development. Such a science of evolution will subsume the academic fields of geology, climatology, and paleontology that are now artifically separated. The primary assumption of this approach is that the *sequence of self-ordering energy flows that have developed over time and whose tendency is the maximum acceleration of the rate of evolution are fundamental* in the history of the earth.

The articles in this issue of the *FEF Newsletter* are the first steps in the direction of a new science of evolution. In this article, I will use the best known part of the earth's history, the last 100 million years, as a case example to show that the seemingly disparate and paradoxical phenomonen of this immense length of time — the disappearance of shallow seas, the formation of the great mountain ranges, the drifting of the continents, the initiation of the ice ages, the extinction of the dinosaurs, and the evolution of modern plants and animals, and eventually man — can be understood as part of a coherent process of self-development. This initial case study can then be use to reach more general conclusions about the process of evolution as a whole.

The Last Hundred Million Years

The 4.5 billion-year history of the earth can be divided broadly into three phases prior to the Neolithic revolution, when social evolution became the predominant form of evolution. The first phase, extending from the origin of the earth to perhaps a billion years later, was the period of the origin of life and the preliminary chemical evolution of the earth. The second period, from about 3.5 billion years ago to 600 million years ago, the so-called Cryptozoic or Proterozoic Era, was the period of development of one-cell organisms. During this time, photosynthesis and respiration were developed and the planet was provided with the beginnings of an oxygen atmosphere.

What is known of these two early periods is mainly inferred

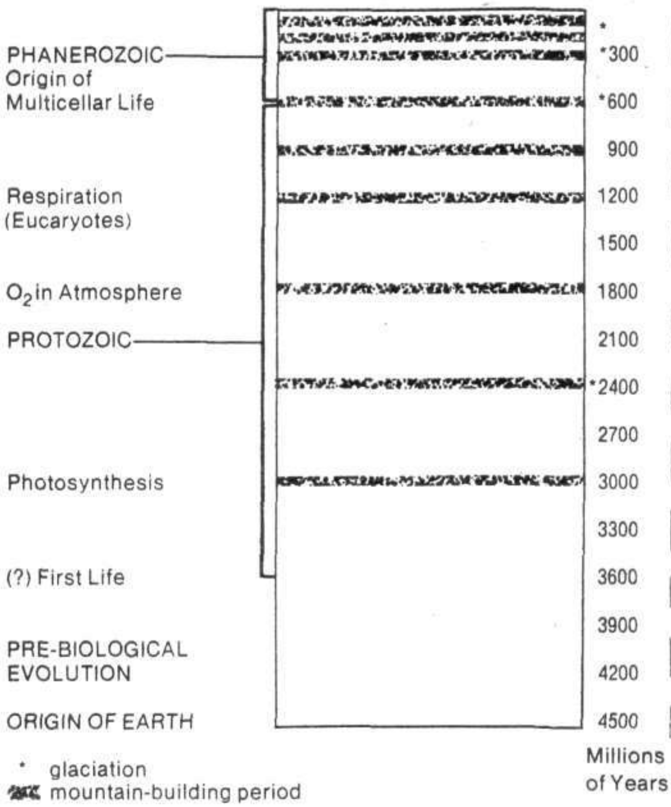


FIGURE 2
The History of the Earth

As is evident from this table, revolutionary changes occurred at an exponential rate over time.

from biochemistry and geochemistry, with progressively less information the farther back in time. However, this knowledge is of immense significance in describing the early self-development of life, a subject that will be covered in a forthcoming *Newsletter* article by Carol Cleary.

The third period of earth history, from 600 million years ago to the Neolithic revolution 10,000 years ago is known as the Phanerozoic Era. In this period multicellular life evolved and spread from shallow sea bottoms to encompass the entire planet. Since these multicellular organisms left behind distinct fossil remains, this period has been closely studied and described by scientists for the past two hundred years.

The Phanerozoic Era, in turn, can be subdivided usefully into three phases. The Paleozoic, lasting from 600 to 200 million years ago, was the period dominated primarily by ocean- and sea-dwelling life. At the very end of this period, wholly land-living animals, reptiles, and plants (the gymnosperms) developed. These life forms dominated both land and water during the next period, the Mesozoic, until 70 million years ago when they were suddenly replaced by mammals and the modern forms of plants, the angiosperms or flowering plants — developments that opened the Cenozoic period.

These subdivisions of time based on biological evolution correspond to the major features of geological and climatological evolution. The Paleozoic Era began with a period of mountain building and cool temperatures, followed by erosion, general inundation, and warming. The same cycle is repeated in the Mesozoic and Cenozoic — with more extreme glaciation and greater mountain building followed by erosions, inundation, warming in the later Paleozoic-early Mesozoic, and then, in the Cenozoic, renewed, even greater mountain building and cooling.

This 600-million-year period is summarized in Figures 1 through 5.

There are several striking features overall. First, the general trend is toward greater ordering: faster biological evolution, colder and simultaneously more differentiated climates, and greater land elevations. The uniform elevations of shallow seas and swamps gave way to sharply differentiated continents and oceans (Figures 3,5) and the uniform climate to sharp climatic zoning and well-ordered circulation cells. (Figure 4)

Second, there are rapid, revolutionary changes that separate one period from another — revolutions in climate, geography, and ecology occurring more or less simultaneously.

Third, there are apparently cyclical tendencies for each revolution to be followed by a period of regression and relative stability.

I will return later to these phenomena. Now I will present in more detail the latest section of the Phanerozoic Era, the period of the last 100 million years which contains in dramatic and concentrated form the most interesting features of the Phanerozoic period as a whole.

The primary tendencies toward ordering in the Phanerozoic — accelerating biological evolution, climatic ordering, and geological ordering — were compressed into this last 100 million years.

Biologically, this last megacentury exhibits no less than three periods of drastic changes in the dominant species. Modern flowering plants replaced the more primitive gymnosperms (whose seeds characteristically lacked fruit) with relatively rapid speed; between approximately the years 100 mbp (million years before the present) and 80 mbp, the gymnosperms were reduced to insignificance. In the animal kingdom, the dinosaurs became totally extinct in a remarkably short period, probably not more than three million years at the very end of the Mesozoic, 65 mbp. Mammals diversified from insignificant mice-like creatures to general dominance in the same short period of time.

A smaller but still profound change occurred in the Miocene epoch, about 20 mbp, when a greatly modified type of angiosperm, the grasses, evolved and within a few million years covered vast prairies. In a similarly short time, the mammals adapted to grass eating, and ancestors of horses, elephants, and other grazers evolved into the dominant mammalian life form. Finally, in the Pleistocene ice ages, human beings developed out of ape-like ancestors in about two million years.

The change in climate during this megacentury, although more unidirectional, was also striking. At the beginning of the period the climate was not only warm (nearly 30 degrees above present temperatures), but almost uniform throughout the world: characteristically dry in the centers of the small continents and moist near the periphery. Ice did not exist anywhere, and the subtropical climates extended to the Arctic and Antarctic circles. An accelerating climatic change brought cooling through the period leading to a glaciation beginning 20 million years ago in Antarctica and climaxing in the extensive ice ages of the Pleistocene. (Figure 4)

Equally great changes occurred in the geography of the earth. A hundred million years ago, at the height of the Mesozoic inundation nearly half of the present land area was under water, including the North American Midwest, much of South America, and nearly all of Europe and North Africa. But beginning about 80 mbp there was a tremendous acceleration of mountain building; the Rockies, Andes, and Alps were developed and there was a rapid and *complete disappearance* of the vast shallow seas with a concurrent growth of land area.

This was associated with a very rapid acceleration of continental drift, in which the Americas rapidly hastened their previously very slow separation from Africa and Europe with a similar acceleration of drift of Africa and India. (Figures 5 and 8)

At the end of this period, in the last 10 million years, another great period of mountain building occurred, sending up the towering ranges of the Himalayas and the Pacific Coast.

The Problem of Self-Ordering

How can this striking phenomonen of self-ordering be explained? On the titanic scale of a planet and hundreds of millions of years there is a process of self-ordering comparable to that observed with laboratory plasmas of a few centimeters in size and microseconds in duration.

For example, compare the development of cross-sections of continents (Figure 3) with that of plasma solitons (Figure 6), phenomena that differ in scale by sixteen orders of magnitude in area and fourteen orders of magnitude in time. In both cases, the direction is contrary to what would be expected thermodynamically — order emerging out of homogeneity and randomness.

Similarly, compare the self-development of the tight and intense vortical circulation patterns today out of the loose and placid circulation of 100 million years ago with the characteristic self-formation of energy-dense vortices in plasmas ranging from laboratory scale to that of galaxies.

In addition to the phenomena of this self-ordering are the dramatic ecological revolutions that punctuate this process, like those at the beginning and end of the Cenozoic Era. How are these to be explained?

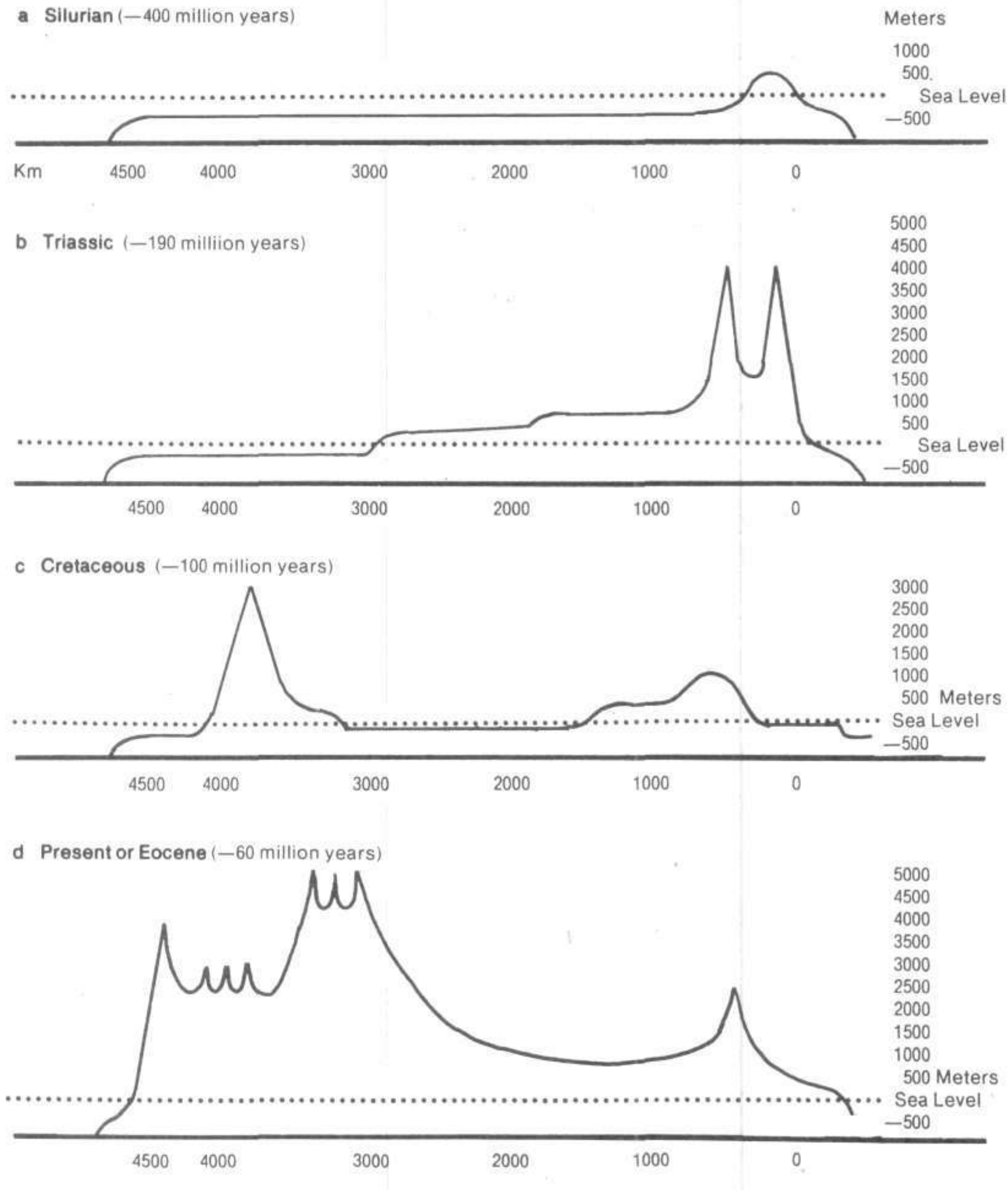


FIGURE 3
Cross-Sections
Of North America
(vertical exaggeration)

These four cross-sections of North America show the change from uniform elevations of shallow seas and swamps to sharply differentiated continents and oceans.

Before attempting to answer this question I will review how the current sciences of geology, climatology, and Darwinian evolution understand such phenomena. These phenomena are anomalous from the standpoint of thermodynamics and Darwinian evolution in that they are not to be expected. On the contrary, existence and growth of continents in the face of continual erosion on the one hand, and the acceleration of biological evolution —especially in ecological revolutions — on the other, have to be given specific after-the-fact explanations precisely because of their unexpected character. If such explanations by contemporary science prove impossible, then the fundamental features of earth history must stand as refutation of the axioms of existing evolutionary science

Buck Passing

The explanation offered for these embarrassing phenomena combine some bits of real scientific insight with a great deal of buck passing, the major burden of the proof falling upon the geologists. The biologists begin by blaming geology for the extinction of the dinosaurs — clearly the environment must have changed or else Darwinian evolution would have proceeded smoothly. The likely candidate is the disappearance of the shallow seas, along whose mild shores the dinosaurs concentrated. Once these seas disappeared, the more rigorous interior climates favored the development of mammals and modern plants.

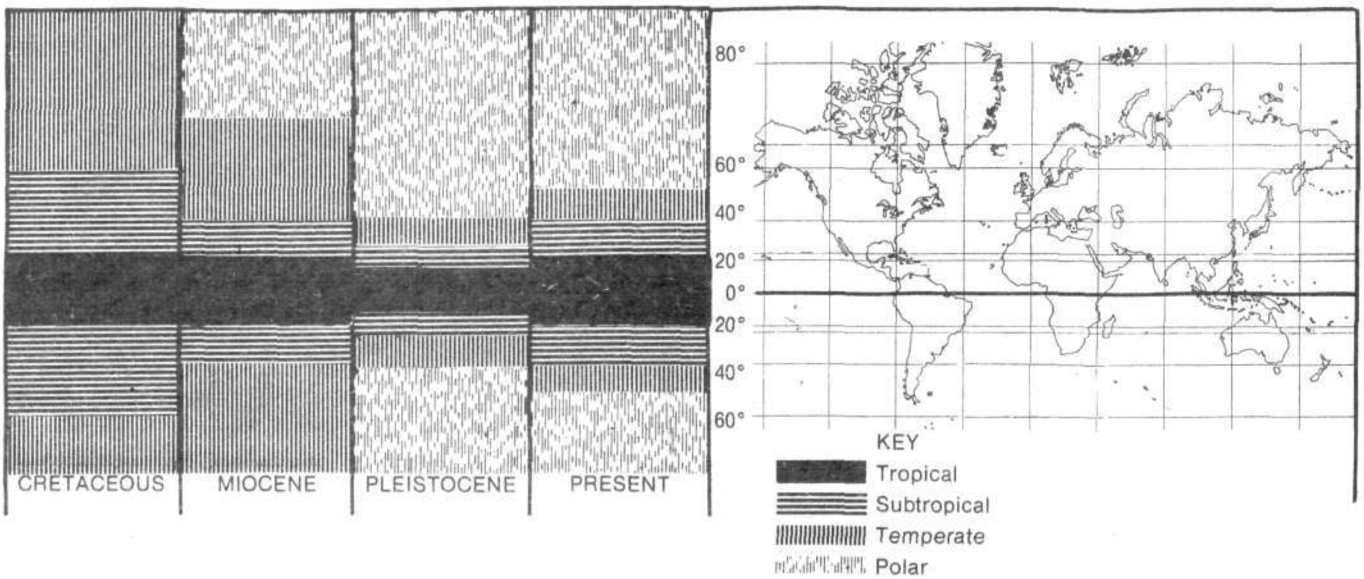
Similarly, the climatologists pass the buck to the geologists on the onset of the ice ages, arguing that it was the increase in land area and elevation during the Cenozoic that contributed to the cooling that led to the glaciations. The geologists themselves consolidate the problem by crediting the mountain-building episode of the late Cretaceous with the rising of land and the disappearance of the shallow seas.

The problem thus reduces to explaining the mountain-building episodes. Here the geologists actually bring forward very good evidence that mountain-building is caused mainly by continental drift, mountains being pushed up by compressional forces on the leading edges of moving continents. (Figure 7a) But what causes the continental drift, and what leads it to start up and accelerate in so sudden a manner? Now the geologists pass the buck off-stage, as it were.

The cause of continental drift is attributed to convection currents within the earth's mantle, which, unfortunately, cannot be directly observed. The starting and stopping of such invisible convection currents drives drift, throws up mountains, thus drying up shallow seas, killing off dinosaurs and creating ice ages!

The Convection Currents Theory

The result of the geologists' process of explanation is to shift the cause of the ordering process on to a deus ex



TEMPERATURE PROFILE

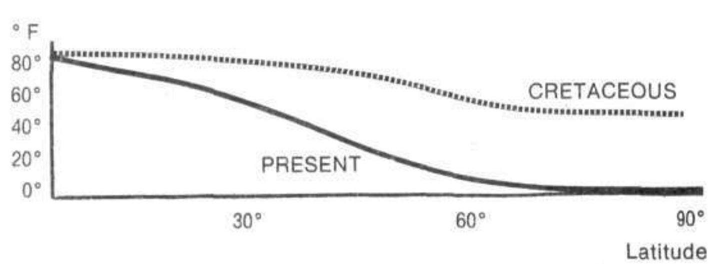


FIGURE 4
Climate Changes

The chart and map above graphically show the changes from uniform climate to the present sharp climatic zoning. Comparative temperature ranges for the Cretaceous and present are charted to the right.

machina that is conveniently self-ordered — the convection currents.

Although there are indeed elements of truth within the various connecting pieces of this explanation, and although the discovery of continental drift was a major breakthrough, the thing as a whole does not hang together with the evidence, fundamentally because it locates the cause of the ordering outside the process itself. First, let's look at the convection cell theory of continental drift.

The theory posits that continents are carried passively by convection cells on large lithospheric plates, 50 to 150 kilometers thick. Six such large cells cover the entire earth, with six underlying plates, each moving from an upward convection flow, where new sea floor is produced at mid-ocean ridges toward a downward flow at ocean trenches. Each such cell is about 10,000 kilometers in length, and seismic studies indicate that the cells cannot be more than about 700 kilometers in depth, since below that point the mantle becomes extremely rigid. The pattern of plate movement, or more precisely of movement of the ocean floor away from the ridges, can be directly measured by magnetic mapping techniques. (Figure 8) The general pattern of continental drift seems to account well for the major regions of mountain construction.

There are a number of immediate problems with the convection cell theory as the *causation* of drift. The cells themselves seem rather remarkable. They are very wide — 12 times wider than high — and would therefore seem very vulnerable to breakup into much smaller cells of the order of 700 miles across. This would lead to 600 plates rather than the six observed. In fact, the plates are as large as they could possibly be and still fit together on a spherical planet.

More important, it is impossible to reconcile the actual pattern of continental drift with convections cells. It is an unarguable fact, for example, that there are presumed upwellings, with no convergent downwellings in between.

Take the situation around Africa. The sea floor spreadings on either side of the continent would imply a downwelling somewhere right in the middle of Africa! However, Africa is definitely not going down the drain (despite certain efforts by various parties to push it in that direction). There is no evidence whatsoever of the compressional stress on African rocks that the convection cells should be producing. On the contrary, East Africa is experiencing definite divergent tensions around the rift zone.

Most important, the convection currents seem to behave over time in odd, inexplicable ways, turning on and off suddenly but above all, growing *stronger* over the course of the Phanerozoic. (The pronounced acceleration of mountain-building and land elevation over time despite various long-term subsidence can be seen in Figure 1.) Yet why, four billion years after the origin of the earth, should such convection current be gaining in strength relatively rapidly over a period of little more than 15 percent of the earth's history? This is certainly very strange behavior for simple convection!

There are equal problems with attempting to saddle environmental changes with the responsibility for biological revolutions. The problem lies not in the extinctions, but in the rapid development of new species that make further evolution possible, and, again, in the increase in rates of evolution. The angiosperms, whose fruits and nuts provide the high-energy food of all mammals (including indirectly the carnivores) conveniently developed right *before* they were needed at the beginning of the Cenozoic, when mammals first evolved.

Mammals themselves, presumably adapted to the new Cenozoic environment and thus under little competitive pressure, nonetheless evolved with catastrophic speed; ancestral forms leading toward bats and whales were already clearly emerging in the first few million years of the Cenozoic. Such rates evolution are not at all reflected in other periods when, presumably, competition was fiercer than in the almost unpopulated world following the extinction of the dinosaurs.*

The fundamental problem lies in the supposition of an exogenous ordering process that imposes order on the basically random development of evolution. Such an exogenous ordering can account for neither internal ordering of the ecology or the continents nor the accelerating rates of development of both.

The Self-Ordering Process In the Biosphere

The concept of exogenous ordering is inadequate to account for the past history of the earth, but if we begin from the assumption that we are dealing with a sequence of self-ordering processes, we will then be able simultaneously to explain the course of biological, climatological, and geological evolution. Such self-ordering processes have been ruled out of consideration by scientists because of the traditional axiom that there is only a one-way interaction among geological, climatological, and biological processes: geology determining climate, climate determining biology, but never the reverse.

Contrary to these beliefs, life *creates* environments more favorable to its own expansion. The biosphere, by developing new modes of reproduction, creates new and more intense energy flows on the surface of the earth which in turn lead to an increased rate of biological evolution.

The method I use here to study such self-ordering processes is to identify at each stage those critical energy flows that lead to an expansion of energy flows for that particular mode of reproduction. These energy flows are mediated by and give rise to historically specific types of individuals, who become the basis for new modes of reproduction and new types of energy flow.

Take the question of the continents and the rise of land elevation. Can we identify a self-ordering process, a self-expanding energy flow here? Yes, if we take into account the effect of climate on geology.

Energy flows in the atmosphere interface with energy flows in the lithosphere by erosional transport. If we consider any slightly asymmetric continent (and all continents are at least slightly asymmetric), erosion, driven by rainfall and transported through the river system, will tend to move material from the high side of the continent and dump it on the opposite side. (Figure 7)

Continental Drift Explained

The accumulation of sediment over time slowly depresses the underlying mantle, which is insufficiently rigid to support great weight. The mantle necessarily will begin to flow out of the way of the descending sedimentary mass (known as a geosyncline). The mantle current thus produced will act assymmetrically on the continent to drive it in the direction of the elevated side, producing continental drift, while part of the mantle flow rises to the surface to form new ocean crust. The leading edge of the continent is crumpled by compressional forces, elevating it further and generating greater

* The usual off-the-cuff explanation is that the mammals evolved rapidly to "fill the ecological niches" vacated by the extinct reptiles. But this explains nothing, since it does not account for the increased *speed* of evolution.

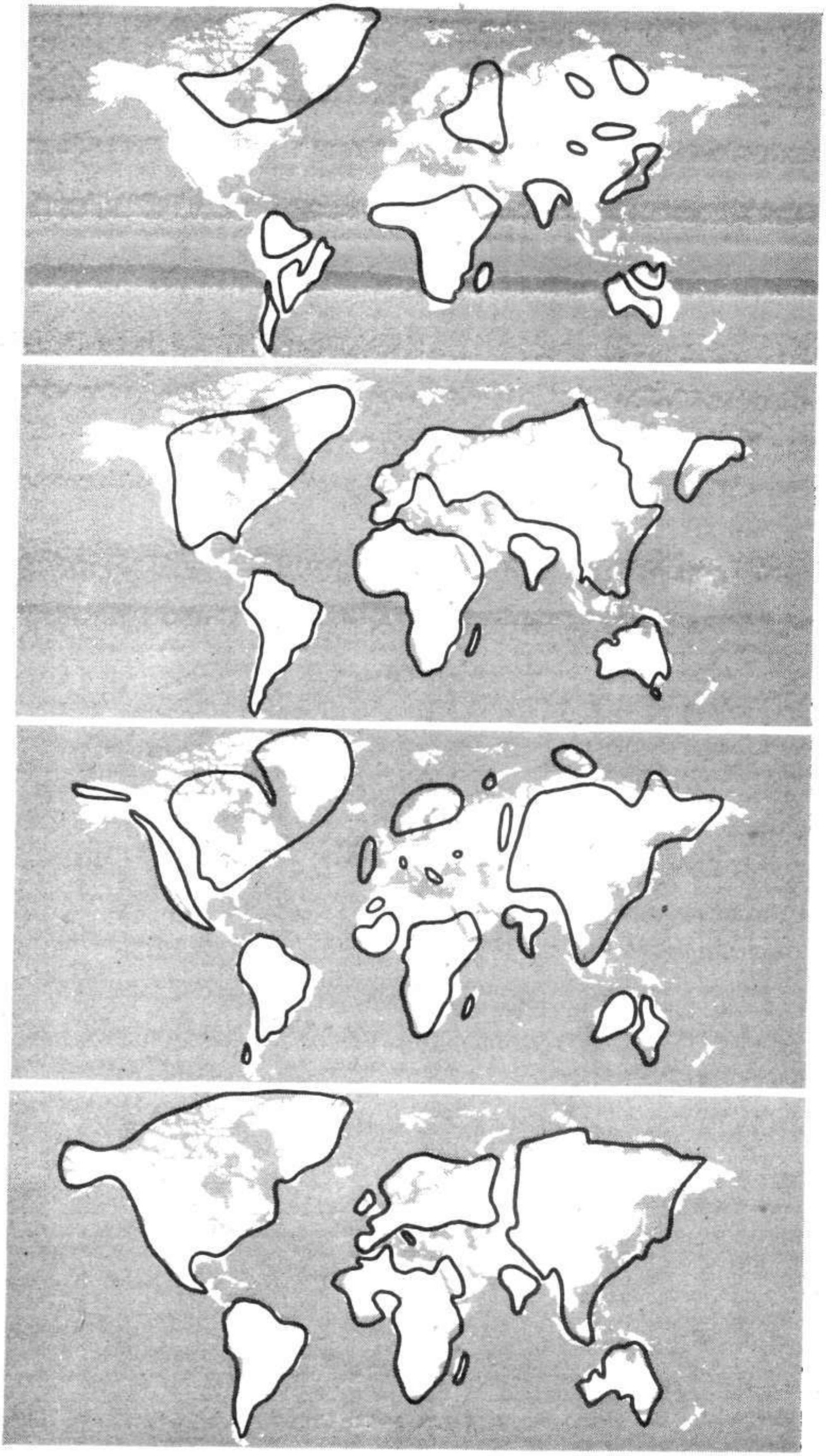


FIGURE 5a
The Development
Of Continential Land Area
In the Phanerozoic
(Continental drift omitted
for clarity)

Period	Millions of years Before Present
Cambrian	600
Triassic	200
Cretaceous	100
Eocene	65

erosion via the elevation and via the generation of greater amounts of rainfall, thus tending to accelerate the drift.

This self-feeding energy flow drives the continents forward in a manner similar to a swimming kick. Essentially generated climatologically, the mantle flow will tend as well to organize the otherwise random heat convectional currents, adding their energy to the supply available to drive continental motion. Qualitatively, this explanation of drift avoids the problems of the convection drive theory; quantitatively, there is enough energy available to drive the known rates of continental drift and tectonic activity.

To take South America as an example: the material flow rate necessary to drive the continent forward at the observed rate of about 2 centimeters per year across a spreading front of roughly 5,000 kilometers per year and a thickness of 50 kilometers is 5 cubic kilometers. In comparison, the combined flow of the Amazon and the Parana-La Plata rivers dump about 2 cubic kilometers of sediment into the Atlantic geosyncline per year.

It is a reasonable assumption that the flow this generates organizes an approximately equal convectional flow. Thus, in the past 50 million years, some 100 million cubic kilometers of sediment have been deposited in thick layers off the South American coast (mainly on the continental slope and rise) and 250 million cubic kilometers of new oceanic crust and lithosphere has been formed beneath the southwest Atlantic.

Similarly in the case of North America, the flow required for a slower drift across a much narrower front is about one-fifth that for South America, and the river flows amount to about one-tenth those of South America, with probably about one-fifth the total sediment load. (Figure 9) In India a similar flow across a narrower front resulted in a high rate of drift.

In terms of energy flows, the immediate energy drive is provided by the gravitational energy released by the slowly sinking sediments. For South America, an average rate of sinking for the entire sedimentary mass of .04 centimeters per year would liberate energy at a rate of about 40,000 megawatts, an excess by at least a factor of 2 of that estimated to be released in continentwide tectonic activity. The energy needed actually to drive the erosional process, breaking up the rock and transporting it, is far vaster — at least 3 million megawatts. The total amount of geothermal energy available to drive convection over the whole of the South American plate, by contrast, is only about one-third of this figure.

The climate has a similarly dramatic effect on the destruction of the shallow seas, a process that was not merely a function of mountain-building. The shoreline of these continental seas was determined by the net balance between ocean erosion and river delta sediment deposits. In Cretaceous times the shoreline tended to oscillate widely, a phenomenon that is climatologically predictable. The expansion of land area during a period in which the interior of the continents were virtual deserts would lead to an overall decline in rainfall as permanent high-pressure zones established themselves over the land. This climatic shift would lead to a fairly rapid decline in sediment supply and a rapid erosion of shorelines, until the continental area became too small to support permanent high-pressure zones and rainfall again increased, pushing out shorelines.

Such oscillations, superimposed on a regular net loss of material from the continent would be reversed only when rainfall (for reasons discussed below) increased, even at the point of maximum land expansion. Even a small shift in total supply of sediment would then prevent the reestablishment of the shallow seas. Such a consolidation of continental land mass would enormously increase the efficiency of the offshore deposits of sediment and thus lead to a rapid increase in the rate of drift. In turn, by increasing rainfall and erosion, this would ensure the permanence of the elimination of the interior seas, or accelerate their elimination where the process had been accomplished only partially.

FIGURE 5b

North America in
The Silurian Period
(400 million years before present)

Maximum submergence of continental land area.

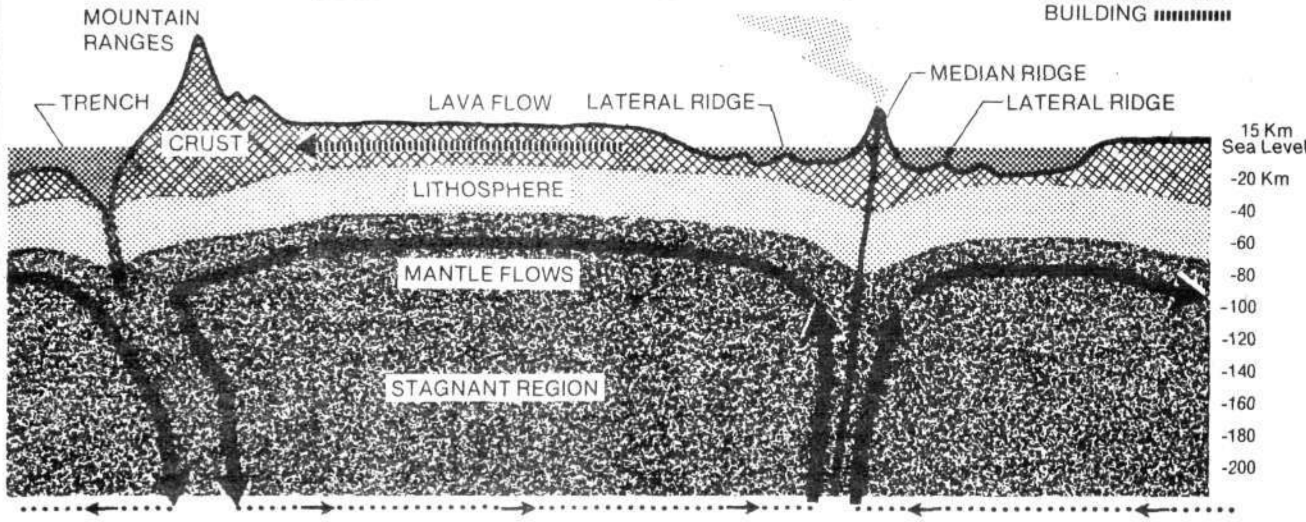
The question remains as to what initiated the increase in rainfall. Here we must turn to the relationship between the bioshpere and climate. Just as atmospheric energy flows dominate and organize lithospheric ones, so they are in turn organized by energy flows in the biosphere. In particular, the transport of water is greatly influenced by the evapotranspiration of plant life, especially that of the present tropical forests. In the Amazon jungle, total rainfall annually amounts to almost double the annual rate of runoff, thus demonstrating the enormous amounts of water, 1 to 2 meters of rain, that are recycled into the atmosphere by the dense vegetation. In general, it is estimated that the water flows into the atmosphere — the overall energy release that drives circulation and produces additional rainfall — are increased by the equivalent of a least 1 meter of rain in going from bare ground to temperate forest.

The Evolution of Angiosperms

The rapid development of angiosperms in the late Cretaceous period brought dense forest cover to ground that was previously lightly covered and replaced conifer with deciduous forest in other regions. The newly evolved deciduous forest was able to thrive under the more seasonal conditions of the interior and could maintain a far greater evapotranspiration throughput.

As these plants came to dominate the landscape, the amount of energy flow in the interior increased to the point where continental low pressure systems could be maintained

FIGURE 7



In the convection current explanation of continental drift (pictured above), the continents are carried passively on the mantle currents. In the climatological explanation of continental drift (pictured on page 37), in contrast, the driving force is located in and above the continents. Erosion builds up sediment which sinks and forces the mantle to

over broader and broader areas during the periodic expansions of land area.

This led to an average increase in rainfall and sedimentary supply as well as an increase in land area. The trend was reinforced by the much greater ability of lowland angiosperms to capture and fix sediment in delta formations. The increase in land area and rainfall, in turn, increased the energy available to the biosphere for more accelerated evolution and increased the mass of biosphere available for further increases in energy flow. The rise in land elevation and the formation of mountain ranges accompanying the increase in continental drift in addition increased the climatic energy flows available, while the seasonality of the climate favored an increased rate of evolution toward the seasonably adaptable angiosperms.

The impetus for the evolution of the angiosperms is clear from the preceeding climatic-geological history of the Cretaceous period. The repeated forcing of the coastal vegetation band into the interior during the periodic inundations of the Cretaceous times inevitably would have set up marginal forest communities that were sufficiently evolved to exploit the more interior climates as the land again expanded. This marginal evolution would tend to increase in importance as in the mid-Cretaceous, the shallow seas transgressed further and further inland.

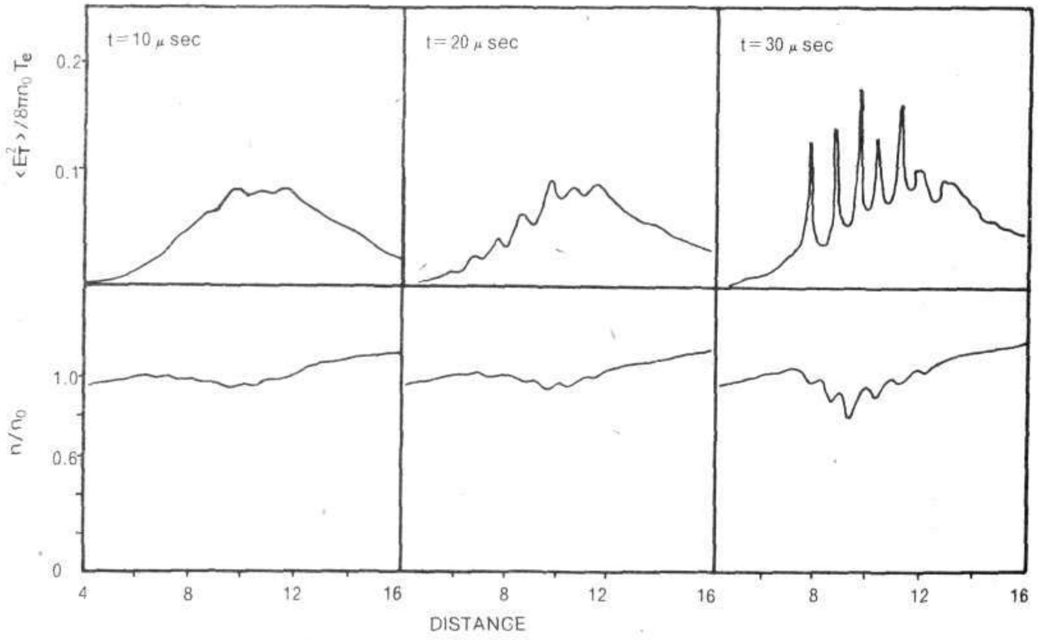
The Necessity for Mammals

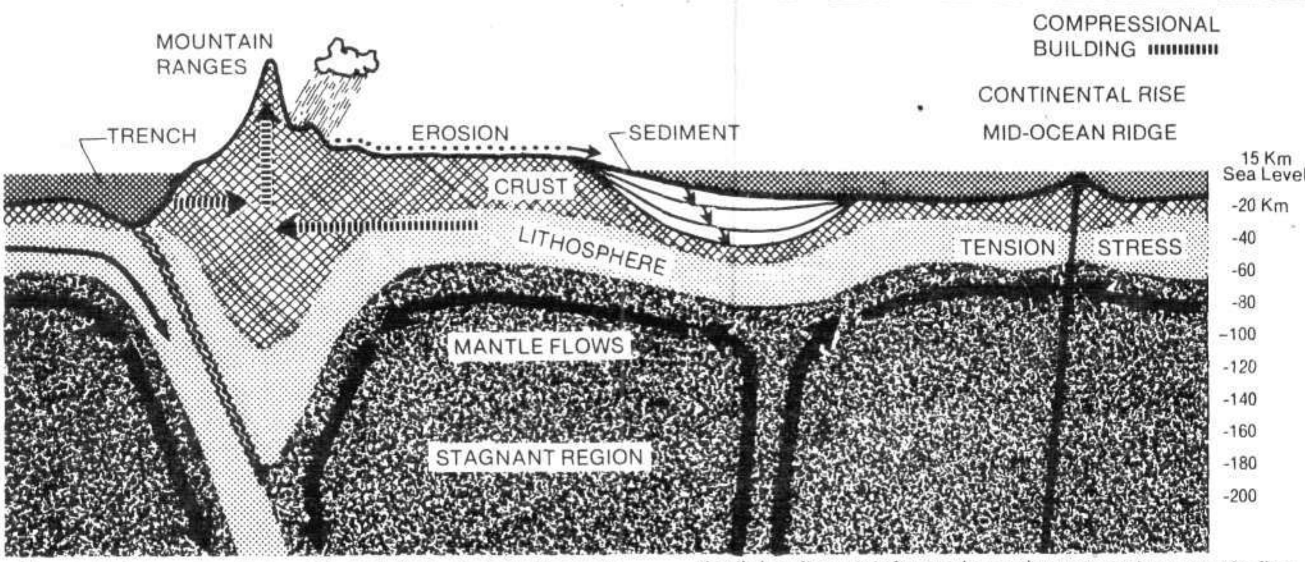
This self-accelerating evolutionary process makes the sudden replacement of dinosaurs by mammals comprehensible. The development of angiosperms and the higher rates of energy flow not only made available the level of energy supply necessary for the higher metabolism mammals, but the development of mammals itself was necessary if the overall process of development were to continue. The maintenance of the carbon dioxide content of the atmosphere requires the matching of any increase in energy throughput of plants by equal increases on the part of animals. At a

FIGURE 6

Plasma Soliton

This graph shows the development of a soliton, a self-ordered structure formed in some high-energy dense plasmas, over 30 millionths of a second. In the three frames at the top, the "mountains" are peaks of the electric field at different times. In the frames at the bottom, the "valleys" are decreases in plasma density at three different times.





flow out of the way, to the left and right of declining sediments. The unbalanced forces drive the continent forward, pulling the oceans apart. A new crust forms at right. The declining flow at left sets in motion secondary mantle flow which drives the Pacific Ocean crust. These drawings show the situation for North and South America.

certain point, such a rate of increase became unsustainable for the slowly metabolizing reptiles, who had a limited adaptability to interior seasonal climates. Either mammals had to have evolved or the entire process would have been brought to a halt. The same process of oscillating climate that provided the potentiality for the development of angiosperms from previously marginal plant forms allowed a similar development of ancestral mammals. Once the diversified mammalian species were established in the interior, and the dinosaurs confined to the relatively shrunken coastal regions, the final rapid transition between the Mesozoic and Cenozoic periods occurred with the replacement of the remaining dinosaurs in the now remnant habitats by the far more metabolically efficient evolved mammals.

To summarize the process as a whole: The problem facing the biosphere at the middle of the Cretaceous was a continual decline in energy flow because of decreasing land area. This limited the solar energy available to land life and limited the sediments available to marine life. The problem arose as a result of the relative limitations of the existing life forms, which in general were capable of existence only on the margins of the continents, leaving the interiors as near deserts.

However, the very process of exhaustion of the previously existing energy flows — the contraction of the land masses — set up the preconditions for the evolution of new life forms. Marginal forests, forced periodically into the continental interior, developed into angiosperms with the capability of utilizing seasonal rainfalls of the interior, and capable of setting into motion new energy flows that could *create* a more favorable physical environment. The expansion of rainfall in the interior as a result of the evolution of angiosperms led to increased sedimentary flow and increased land area, at the same time increasing the energy available for more evolution. The elimination of the continental seas, or their dimunition, forced more sediment onto the continental margin, vastly accelerating continental drift and setting in motion a second energy flow chain. (Without this second chain, the increased rainfall could have led only to a more rapid decrease in interior land elevations.)

The increased drift led to increased mountain formation, still greater rainfall, and even greater sedimentation and land area, thus further accelerating evolution. As the mass of vegetation and the resultant demand for carbon dioxide increased, the slow metabolism of the dinosaurs became increasingly restrictive of the whole process at a time when their coastal habitats were being greatly reduced in size and supplies of energy for mammals was vastly increasing. The result was a very sudden efflorescence of mammalian evolution, making possible still greater development of continental forests and leading to the rapid extinction of the now marginal dinosaurs.

In this way the biosphere developed an entirely new mode of overall reproduction, which was to characterize the next period, the Cenozoic. New energy flows, mediated by new types of biological individuals, brought into being new types of climatological and geological individuals as well — a more differentiated environment to mediate the increased energy flows demanded by the new mode.

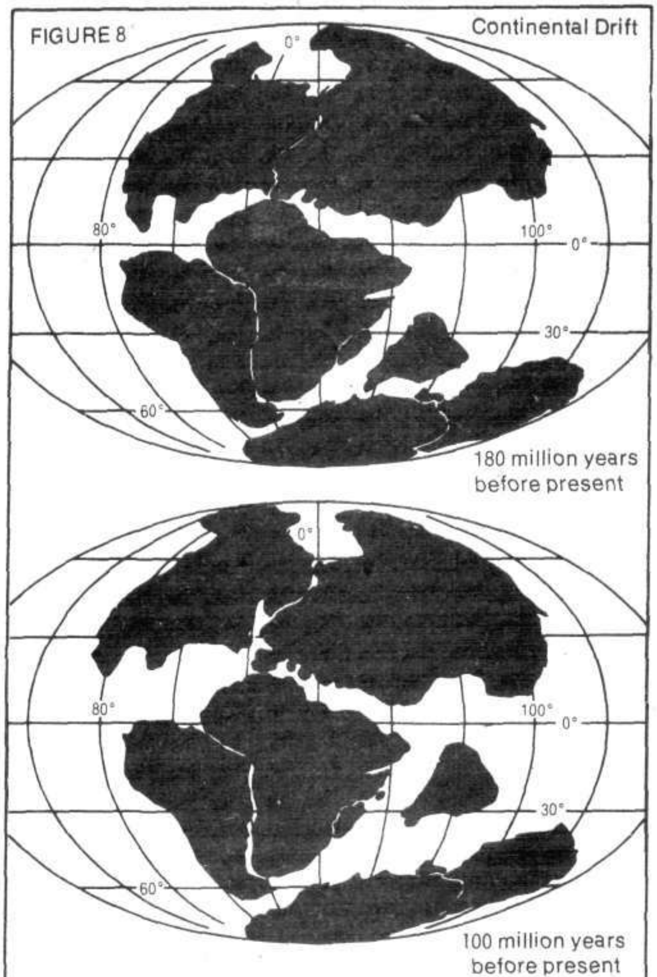
The Pleistocene Revolution

The ecological revolution of the early Cenozoic can be understood in terms of self-expanding, self-ordering energy flows. Can this same method be applied to the rest of the Cenozoic, and, for that matter, to the whole of the Phanerozoic?

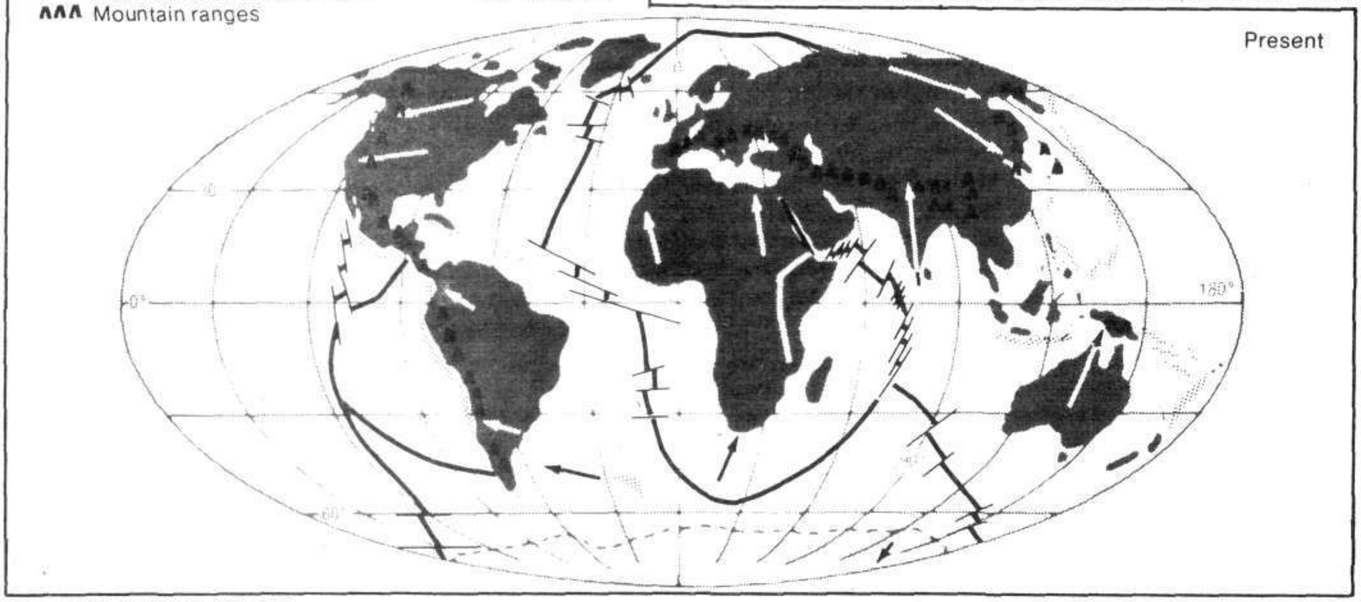
The primary problem of the later Cenozoic is obviously the accelerating cooling trend and increasing climatic differentiation. There is no doubt that much of the reason for this trend is the existence of large amounts of relatively high land. This tends to isolate the poles by interfering with ocean circulation; it creates areas for the accumulation of snow; and, most significantly, it increases air circulation and directly aids snow formation by increased precipitation and, above all, by the cooling that accompanies increased precipitation. Precipitation leads to cooling both because of increased cloud cover (this is probably the most directly significant factor) and because solar radiation absorbed at the surface by water is partially reradiated into space when condensation occurs high in the atmosphere.

The purely geographical explanation, however, cannot be the whole story, since it is clear that cooling to the point of initiating Antarctic glaciation occurred during the period 60 mbp to 20 mbp, a period in which the land was gradually

FIGURE 8 Continental Drift



This series shows the past locations of the continents and the present direction of drift. Note how little drift occurs in the first 180 million years compared with the acceleration after 100 million years ago.



eroding from its maximum early Cenozoic heights. Again it is necessary to take into account the domination of climatological energy flows by those generated in the biosphere proper. The greater generation of rainfall with continued biological evolution of vegetation in evidence throughout the Cenozoic led to the gradual decrease of temperature *despite* the somewhat less favorable geological situation as the continents again adjusted to a more steady energy flow situation.

The relative limitations of this process were inherent in the limitations of the existing life forms. The most interior regions of the continents, although hemmed in by the development of the deciduous forests, remained too dry for existing plant life. The evolution during Miocene times of fundamentally new forms — the grasses — opened up a new period of revolutionary change. Again there was a rapid biologically driven increase in rainfall, as prairies covered previous deserts. The amount of energy flows available to animals on the prairies was more than ten times that of the forests, and with the evolution of the grazers, animal biomass increased in step with the spreading prairies. The rapidly increasing rainfall led to a swift decrease in overall temperature, initiating glaciation in Antarctica.

Simultaneously, the renewed increase in sediment runoff led to another renewed increase in drift and tectonic activity — the Pacific Coast region, the Rocky Mountains, the Andes, Alps, and Himalayas were all undergoing massive uplifts. This trend accentuated the climatic shifts, culminating in the ice ages and the present semiglacial climate. Once underway, the glaciation tended, up to a point, to be self-feeding, both because of the immense cooling effect of the ice caps and because the sharp differentiation of climate further increased overall air flows and thus precipitation.

From the standpoint of the bioclimatological energy cycles, it is also possible to explain the characteristic oscillations of glaciation that have regularly recurred at 100,000-year intervals since the Pleistocene began 2 million years ago. Such cycles are in fact to be expected, since it is clear that at a certain point the further expansion of the ice mass will do more to constrict the area available to life than is compensated for by the increase in rainfall. In fact, the interior of the ice sheets at greatest extension probably contributed almost nothing to water circulation, with cyclonic activity concentrated around the edge. When the point was reached that rainfall began to drop, the contraction of the ice would begin and proceed quite rapidly, since the barren tundra left behind would continue to reduce water

CONTINENT	RIVER	FLOW (cm /sec.)	SEDI-MENT	DRIFT RATE (cm/year)	DRIFT FRONT (km)	DRIFT VOLUME (km^3)	DRIFT VOLUME / SEDIMENT
N. America	Mississippi	20,000					
	St. Lawrence	15,000					
	Total	35,000	0.4	1.0	2,000	1.0	2.5
S. America	Amazon	250,000					
	La Plata	100,000					
	Total	350,000	2.0	2.0	5,000	5.0	2.5
Africa	Congo	70,000					
	Nile*	-15,000					
	Total	55,000	0.8	1.0	5,000	2.5	3.0
India	Brahmaputra	20,000					
	Ganges	10,000					
	Indus	10,000					
	Total	40,000	0.6	2.0	1,500	1.5	2.5

* counterdrift

Figure 9

This table shows the ability of known sedimentation rates from major river systems to account for rates of continental drift. Note constant relationship (far right column) of drift and sediment rate.

flows in a broad area and preserve high-pressure continental weather patterns. Not until the ice cap had disintegrated — or nearly disintegrated — a process taking not more than 5,000 or 6,000 years, would there be sufficient recovery to make possible the reestablishment of moist continental conditions. At this point, cooling would resume, slow at first, and then more rapid, after the reestablishment of the ice cap.

The extremely rapid fluctuations in climate, especially during the collapse of the ice sheets (the last such collapse in North America occurred almost entirely within a 3,000-year period) introduced changes in energy flow patterns at least a thousand times as rapid as those of previous epochs. This rapid oscillation necessitated the development of faster modes of evolution — the development of intelligence and social evolution. The great herds of the glacial and immediately preglacial periods provided the concentrated energy required for the development of intelligent life, and the rapid fluctuation of the margin of forest and grassland provided the preconditions for the development of the most advanced of the forest mammals — the apes — to begin the evolutionary course toward humanity.

The Phanerozoic As A Whole

This case study of the last 100 million years has given us the fundamental processes with which to outline the main tendencies in the entire Phanerozoic period. The most prominent feature of that long era, the tendency toward geological and climatological ordering, is now comprehensible. This tendency is a reflection of the accelerated biological evolution toward conquest of land areas and the consequent increase in energy flow rates.

It is clear from consideration of the pre-Cambrian period that we are dealing with an acceleration by biosphere of processes already occurring previously, but at a much slower rate. (See Figure 2) (The long-term, periodic mountain-building episodes of the pre-Phanerozoic, for example, relate to the periodic collisions of continental drifting under the influence of very slow inorganic erosional processes.)

As a whole the Phanerozoic was characterized by the development of multicellular animals to cover a greater and greater variety of environments on earth, and by so doing, create a greater and greater amount of climatological energy flow. The period of the Paleozoic and the Mesozoic-Cenozoic can best be treated as two attempts to resolve the problem of maintaining high energy flows, with the first try only partially successful. Throughout, the general problem that had to be overcome was the entropic tendency toward universal flooding of land areas.

The primitive invertebrates of the early Phanerozoic were limited in their habitat to the shallow waters of the continental seas and coasts and were dependent on continental sediments for plant nutrition. The leveling of the continents by the Silurian period tended to greatly reduce this flow. The evolution of plant life on land, and later animal life, during the second half of the Paleozoic brought about on a smaller scale the climatic changes that were to characterize the late Mesozoic — increased rainfall, mountain building, and land area. The convergent tendency of continental motion at that period considerably assisted in this process.

However, in the late Paleozoic, unlike the latter period, the biosphere was unable to evolve the modes necessary to maintain a high energy flow environment. The newly evolved reptiles and gymnosperms of the Permian, although advanced compared with earlier species, were ill-equipped to handle the differentiated climate that resulted. Unable to advance, the ecology collapsed — glacial erosion leveled the mountains; the interiors of the continents were turned into tremendous deserts; and life was limited to the marginal lands.

Evolution As Self-Organization

I will now take a step back from the predicates of earth history and directly address the nature of the evolutionary process on the bases of the evidence presented above.

(1) *Evolution occurs as a sequence of self-expanding energy flows.*

Energy for the biosphere is not a fixed entity, but is defined for each phase of evolution as those flows that characterize the expansion of the entire biosphere's *capacity for further evolution.* These historically specific energy flows constitute the mode of reproduction by which the biosphere modifies its environment to promote further evolution, *differentiating* characteristic geometrical orderings out of its surroundings in such a way as to further increase the rate of differentiation.

The rate of increase of such energy flows, or the rate of self-ordering, defines a unique objective measure of the *progress* of evolution at any given point, and the general tendency of evolution is the maximization of this rate of evolution.

Thus the pre-Phanerozoic era was characterized by the energy flows that resulted in the chemical differentiation of the environment and the production of free oxygen, while the Phanerozoic was characterized by energy flows leading to the geographical and climatological differentiation of the earth, that in turn led to the formation of continents and global climatic circulation patterns.

(2) *Each individual phase of evolution tends to be relatively limited.*

Eventually the chemical differentiation produced an overwhelmingly oxidizing atmosphere and the Phanerozoic resulted in a climatic environment of maximum differentiation. There was a similar process with the subphases of development, as shown above. In the Pleistocene, biological evolution was shown to be too limited in its maximum rates of development to be extended further.

(3) *New types of energy flow, new modes of reproduction come into existence on the basis of the individuals differentiated during the previous phase.*

The final "perfected" result of the previous process of evolution becomes a particularized basis for the new mode of evolution.

In the course of biological evolution such new modes have developed repeatedly. The perfected result of the process of the origin of life — primitive bacteria — were taken in the next phases as a specialized metabolic variant of an organism capable of fully exploiting all available chemical energy — the eucaryotic cells. This perfected result was in turn taken as a specialized one-cell case of multicellular life, resulting in the Cambrian development of invertebrates and multicellular plants. These, in turn, developed from shallow sea-dwelling organisms into organisms capable of living fully on land or sea, whose perfected examples were the reptiles and gymnosperms of the Mesozoic. And these, of course, became specifically warm-or moist-climate specializations of organisms capable of existing in any climate on earth — the mammals and angiosperms. Finally, these fixed-species animals became specializations relative to the development of a species capable of modifying itself socially to deal with all environmental — human beings.

Each successive mode of evolution, by commanding a qualitatively greater variety of reproductive relations — and by being more differentiated — was capable of qualitatively higher rates of differentiation and of energy flow.

(4) *The succession of one mode of reproduction by another occurs not gradually but in sudden revolutions in which previously marginal energy flows become dominant and new laws of evolution take over, subsuming the old.*

That this is necessarily the case follows from the much greater rate of evolution of the new mode relative to the old. Thus the climatological evolution of the later Cenozoic, for example, came to dominate and modify the laws of geological evolution of earlier periods; or, to take a more obvious example, social evolution now entirely dominates previous modes of biological evolution.

The conception of biological evolution stated here entirely contradicts Darwinian notions and related ideas of genetics.

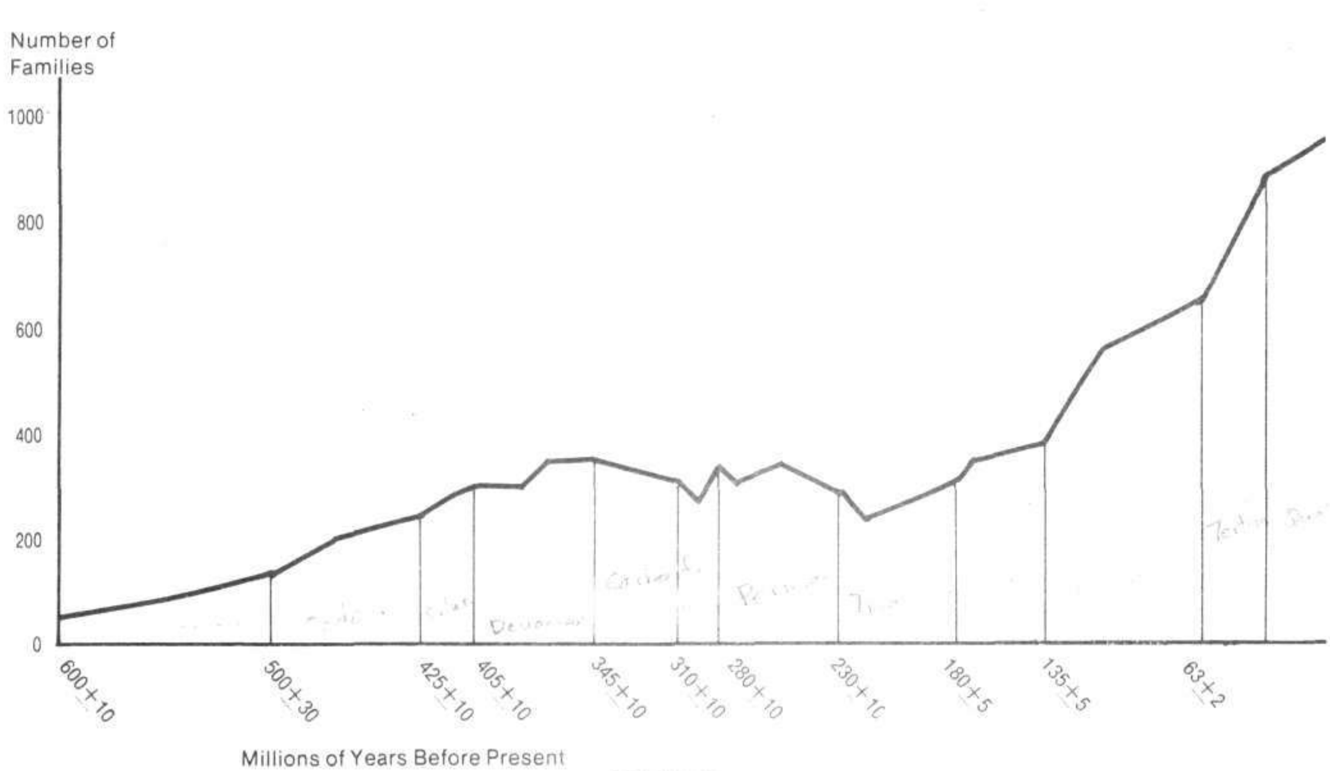


FIGURE 10
The Rate of Evolution

The expanding curve at right indicates how the number of major families of fossil animals increased through geologic time. The sharp decline around 230 million years ago reflects the most dramatic of several mass extinctions.

No conceivable amount of random mutations, selected out by "survival of the fittest," "competition," or "differential reproduction" of the individual members of individual species possibly could have conspired to result in the coherent shifts of energy flows and modifications of the environment that repeatedly characterize the actual record of the earth's history. The most rapid evolution occurs, not when the so-called competition is fiercest and resources most scarce, but when new energy flows are most rapidly expanding and resources are most available.

Biological evolution and its genetic mechanisms must be radically non-Darwinian. The criterion for the survival of an individual species must be its contribution to the overall energy flows of the global ecology of which it is a part, and its rate of evolution must be determined not randomly but by qualitative leaps in the reorganization of genetic material in response to increases in available energy flows. Experimental evidence for the occurrence of just such non-Darwinian evolution is documented in Richard Pollak's article in this issue.

Only such a conception of biological evolution is coherent with what we already know of the process of human social evolution. The "equilibrium of nature" toward which the advocates of zero-growth want human society to devolve never existed anywhere in nature, any more than it did in human history. Progress, the continuous struggle against entropy and equilibrium, has characterized biological evolution at every phase as it has social evolution. For the biosphere just as for man there are no fixed resources nor fixed definitions of energy supplies. *Just as man does today,* the biosphere has created for itself new energy flows.

To ensure the further evolution of the biosphere, human beings must use their knowledge of evolution to put under conscious guidance the biological and physical development of earth.

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FEF COMING EVENTS

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Conference On

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Evolution—
Beyond Darwin and Mendel

Dr. Richard Pollak

FIGURE 1
Fourth generation flax plants of the two extreme varieties induced by fertilizer treatments: left, NPK; right, NK.
Source: Heredity (1962)

The question of biological evolution is of necessity located within the larger question of the self-development of the universe, and at the same time is essential for providing insights necessary for furthering that very process. Understanding generated in the biological sciences will point the way to the solutions for nonlinear processes in other disciplines. Many of these are key to the development of fusion power, which will usher in a new expansion of the energy flows through the biosphere and a new manifold of existence. In turn, as a fusion economy is developed, this will represent the basis of the breakthroughs to a still higher-order manifold.

Current biological dogma says that evolution proceeds in a quantitative, linear fashion under pressures that are continually pushing toward the establishment of an equilibrium situation. Today's neo-Darwinian theories hold that new organisms evolve to fill particular environmental niches where the species can most successfully "compete" for the privilege of exploiting that niche, while those less adapted are doomed to extinction by the pressures of natural selection. Although there are raging arguments among evolutionists about the various features of this scenario, the overall conceptual framework is as posed above. This neo-Darwinism is totally inadequate to account for the essential, invariant qualities of evolution: an *expanding* biosphere that undergoes nonlinear processes which in turn are the basis for the self-developing nature of the successive transformations.

There are similar conceptual problems in the domain of molecular genetics. The central dogma for these geneticists is that the DNA →RNA →Protein relationship within cells is the basis of all cellular activities and that any cellular transformations result from modifications of the read-out of the master (DNA) computer tape. Following this litany, molecular geneticists have become lost in a Ptolomaic game similar to the one that plagues atomic physicists — the search for *the* master gene (or quark, and so forth) which controls the gene, which controls the gene, which controls.... Variations on this theme — such as RNA→DNA→Protein, or controls at the level of the RNAs — are locked into the same reductionist conceptual framework. Such schemes occupy many researchers' efforts, but for naught: without examining the epistemological framework upon which these efforts rest, such researchers will generate endless amounts of scientific data but no understanding.

Since 1962 there has been an increasing body of literature in the biological sciences concerned explicitly with the *experimental refutation* of the fundamental aspects of neo-Darwinian evolution. Although the various articles have appeared in reputable journals, they have been systematically ignored — not refuted — by nearly all workers and writers in the field.

The flax experiments, begun in the 1950s, are part of this ignored experimental literature. These experiments are specifically addressed to the question of whether it is possible for particular environmental stimuli to induce changes in an organism that are heritable. There are other examples where such changes were induced, but most of the cases extant in the contemporary literature can be ascribed to mechanisms consistent with the current neo-Darwinian dogma of molecular genetics and molecular biology in general. I will briefly describe this gospel, since the flax experiments so clearly refute it.

The dogma states that the cells of an organism undergo change by means of an off-on control mechanism, known as the Jacob-Monod model.* This "switching" occurs as parts of the DNA (deoxyribonucleic acid, the genetic material) are bound by or freed of certain repressor molecules. If, in response to the presence of other molecules, the repressor molecules leave the DNA, the DNA is then available for its encoded message to be transcribed. This transcription process and subsequent cellular events then produce proteins that, as enzymes (organic catalysts), are responsible for cellular metabolism. Another basic component of the dogma is that one gene yields one enzyme.

The molecular basis of evolution, according to the dogma, is random mutations in the genes which, in the process of natural selection, result in changes in the populations of the ecology.

The flax experiments have irrefutably demonstrated that specific sets of environmental conditions can bring about a change in the energy-throughput capabilities of the affected organism and that even in the later absence of these special conditions that change has proven heritable on a continuous basis for the past 17 years. Further experiments have demonstrated that specific, substantial changes in the DNA content per cell are associated with these environmental conditions and that these DNA changes apparently have a mediating, albeit transient, role in the generation of the new genotypes. These DNA changes suggest a new understanding of fundamental aspects of molecular genetics.

The Flax Experiments

The initial experiments were begun in 1953 by A. Durrant to determine if, in his words, "environmentally induced heritable changes" would occur in response "to the application of all combinations of nitrogen, potassium, phosphorous, and calcium, the object being to obtain information on their homeostatic properties, gene-environment interaction and dominance, etc. for a number of characters in the different environments....The (Stormont Cirrus) seed was sown in boxes in a warm greenhouse where they received (rich) solutions of commercial fertilizers and the young plants were transplanted (after five weeks) into field plots which had received the same commercial fertilizers as the plants had received in the boxes. Each individual was traced from the seed to the mature plant so that selection could not occur unnoticed and seed contamination was prevented."(Durrant, 1962)**. The fertilizers used were ammonium sulphate (N), granular triple phosphate (P), muriate of potash (K), and lime for calcium as single inputs or in various combinations.

Seeds were collected from the individual flax plants that had received the experimental fertilizer treatments, and these seeds where then tested to determine if the treated plants had undergone changes that would be detectable in the following generations. Durrant did this by growing the harvested seeds in various conditions; for example, seeds from the N-treated plants were grown in N, K, or P, and so forth, and the resultant plants analyzed.

Durrant found that the weights of all the second generation plants that were from the seeds of the first generations plants treated with NPK fertilizer were larger than any of the other treated plants, no matter which regimen the second

*This is explained in more detail below. Also See Figure 5.

**Most of the findings referred to in this paper are based on the work of A. Durrant, an experimental agricultural botanist at the University College of Wales in Aberystwyth.

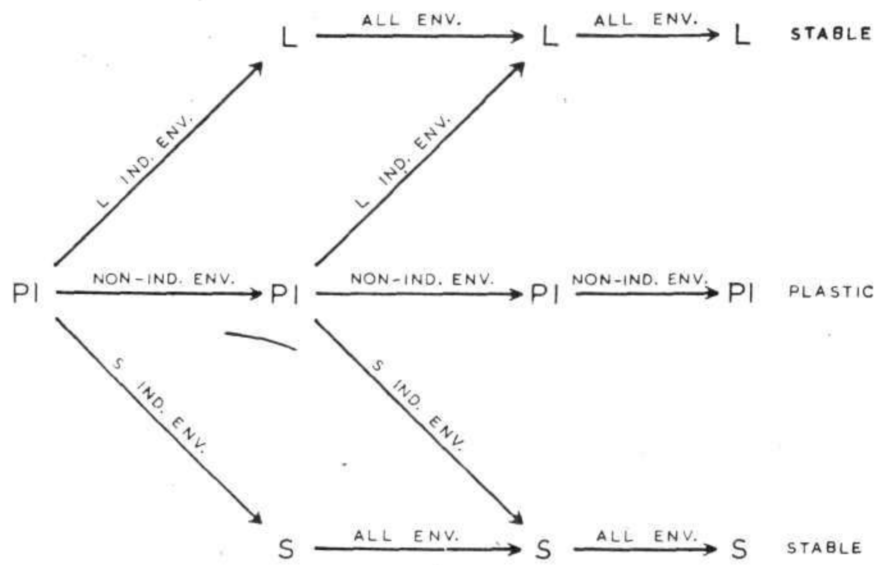


FIGURE 2

This diagram shows the environmental induction of large (L) and small (S) stable flax genotrophs from the plastic (Pl) genotroph.

L ind. env: L-inducing environment
S ind. env: S-inducing environment
non-ind. env: noninducing environment

Source: Heredity (1971)

generation plants were grown in. (See Figures 1 and 2) Furthermore, if the seeds from any second generation plants were grown in a variety of conditions, the third generation plants that were the descendants of the NPK first generation plants (that is, the grandparent plant) were still the largest, regardless of which fertilizer used on the second generation (parent plant).

In the other direction, the third generation descendants of the *original* NK-treated plant were the smallest of all the descendants and also were not significantly affected by the treatment accorded the immediately preceding (parent) plant. That is, the initial treatment of noninduced plants with heat, light, and the specific fertilizer containing NPK resulted in the heritable change of increased size for its plant descendants *for as long as 17 generations* from the original treatment, to the present. This was the case regardless of what treatment was given the intervening generations of plants, when compared to plants that were not descended from "induced" plants. The NPK-induced plant lines were approximately two times the size of the control plants

Similarly, NK-induced plants yielded smaller plants for this period, compared with uninduced plants, regardless of the conditions under which the intervening generations were grown. The plants of the NK line were usually about one-half the size of the control plants.

Differences in plant weights between the NPK and the NK plants were usually about fourfold, but occasionally as great as eightfold or as little as twofold within a given generation. This variation from generation to generation is due to factors like drought, warmth, soil conditions, and so forth. Within the types of NPK or NK the plants are very uniform. In fact the variation *within* the group of NPK plants and within the group of NK plants is statistically insignificant compared with the differences *between* the groups.

The other fertilizer regimens initially resulted in plants of intermediate size. A later finding using the P fertilizer in acidic soil induced a plant line with the same small characteristics as the NK, and this line has subsequently been used in place of the NK line. Further experiments have shown that the intermediate lines demonstrate no induced characteristics and are similar to the original stocks in that they respond to the NPK and NK treatments by yielding induced large and small heritable lines. Because they have maintained their ability to respond to the inducing conditions, they are classified as plastic (Pl) types, and the others are classified large (L) and small (S); that is, there is plasticity in the intermediate types and stability for the extremes.

These results indicate that experimentally defined environmental stimuli on an original parent stock produce a heritable, genetic transformation that yields two distinctly different genotypes with concomitantly differing phenotypes. To examine the distinct quality of these evolved genotypes, reciprocal crosses were performed. NK plants were crossed with NPK (NK x NPK; NPK x NK), as well as NPK x NPK, and NK x NK, and the seed then grown in a common compound fertilizer. It was found that the crosses between the two extreme types generated plants of the mid-parent value.

The reciprocal crosses of NPK and NK were nearly identical in weight, indicating that the factors responsible for the NPK and NK differences are transmitted equally well by both the male and female sex cells — an argument against maternal inheritance being responsible for the inducing effects. Throughout, the L and S appear to behave as two distinct genetic types, because of their demonstrated long-term stability, uniformity, and the reciprocal crosses.

The Question of Selection

Several obvious question on the transformations have been answered by the original experiments and others have been answered in later experimentation. The foremost question is whether or not these genetic types represent the result of a process of *selection*. The original experiments point to the unfeasibility of selection as the agent responsible for the appearance of these two types, and subsequent experiments on the DNA changes in the induced plants, described below, also refute this consideration:

(1) The plants of either L or S type show a high degree of phenotypic uniformity within each group; and within each type the weights do not vary to any significant degree.

(2) The experimental induction of the L and S types is highly repeatable in separate experiments; the original experiments were repeated over a period of several years with the same results as the initial experiments.

(3) Changes in the DNA content per cell suggest that specific environments cause reproducible metabolic alterations that are specific to the resulting heritable changes noted.

(4) Individual seeds were subjected to highly defined environmental conditions that produced alterations of the hereditary constitution of the resulting plants in a highly specific and predictable fashion. For selection to have occurred, the environments would have had to have *chosen* those seeds whose already predisposed genetic makeup made them most likely to grow in the particular environment. At the same time, other, genetically nonfavorable mutated seeds should not have responded to the experimental environment. The fact is that one homogeneous group of seeds (Pl) could and did respond with equal facility to the two specific, symmetrically inducing environments to yield distinctly different plant lines which continued to reproduce in a homogeneous fashion. This unequivocally rules out selection as the process by which the generation of these distinct plant types occurred.

Maternal Inheritance Ruled Out

The question of maternal inheritance (that is, the effects of the environmental conditions on the parent plant affecting the offspring through a *transient* alteration of the seed) was addressed in three ways:

(1) Attempts to reverse the induced types by growing the NPK in NK conditions, and vice versa, were unsuccessful. This indicates that the original inducing conditions effected permanent genetic changes. Were the affects due to maternal inheritance, the reversal of growth conditions should have resulted in a reversal of types produced.

(2) The long-term stability of the types, whereby several generations of growth in noninducing conditions does not result in a reversion to the original type, also rules out maternal inheritance as the factor responsible for the altered phenotypes produced. If maternal inheritance was the responsible agent, these neutral growth conditions over the long period should have diluted out these effects and a subsequent reversion should have occurred.

(3) Grafting experiments, grafting NPK scions onto both NPK and NK stocks and NP scions onto NP and NPK stocks, resulted in each component's growth pattern remaining consistent with its induced genotype. That is, the stock had no effect on the scion. Additionally, seed was taken from the stock and scion of each of the plants of the four types of grafts and sown in common compound fertilizer conditions. In all causes the resulting plants showed the same characteristic differences in weight that occurred between ungrafted NPK and NP plants. Again, were maternal influences responsible for the characteristic of each type, these results could not have occurred.

DNA Changes

The DNA content of the cells of each of the plant types was then examined in order to further define the events in these inductive transformations and gain some insights into the mechanisms that might account for the basis of the heritable changes. Using spectrophotometric methods it was found that the L plants contained 16 percent more DNA per cell than did the S plants, with the DNA content of the Pl intermediate to the two. Using arbitrary units, the values obtained in one of many sets of experiments showed the following DNA content: for L, 93.6; S, 80.5; Pl, 85.8.

This finding immediately raises several questions: What is the relationship of the inductive environments and their various components to the generation of the new DNA values? How closely correlated are the changed DNA values and the changes in the phenotype? Are there any specific genes associated with this changed content?

First Five Weeks Critical

To answer the first question, cells from the apical shoots of germinating plants were examined for the first five weeks. It was discovered that during this period the nearly symmetrical divergence of the DNA values from that of the Pl types occurred. In other words, with the appropriate fertilizer and greenhouse conditions, there was a steady change in the expected directions for the DNA of the plants undergoing the inductive transformations, reaching the expected values at the end of the first five weeks. This is the time that the plants usually are replanted in the field, and the offspring of these plants show the expected heritable size changes from this point on, even if they are no longer subject to the special conditions.

However, experiments on the growth of the already induced plants under a variety of conditions revealed a surprising and important result: if the germinating plants of the L or S types do not enjoy the warmth of the greenhouse during this early period, they begin to lose their characteristic DNA values. Grown out of doors for three consecutive generations the DNA content per cell reverts to that of the Pl types while the induced plant remains constant for its differentiated weight characteristics. The L loses its extra DNA, and the S regains its lost DNA; but the L types are still approximately four times the weight of the S, with the weight of the Pl types intermediate to both.

The amount of reversion during each generation grown out of doors is precise, and repeatable, and results in no detectable differences in the DNA values per cell for any of the three types (Pl, L, or S). Furthermore, the reversions can be stopped at any point by growing the germinating plants in the greenhouse for the first five weeks; the divergent DNA values can then be reinduced back to the inducible limits. "In no case has the induced plant weights of L and S reverted to the original plant weight, nor have there been any other observable changes in their phenotypes at the third generation." (Joarder 1975)

Apparently the original inducing conditions cause a profound change in the physiology of the young plants. This results in an alteration of the metabolic relationships such that substantial changes in certain of the biochemical constituents (such as DNA) are affected. However, a stabilized change in the metabolic relationships (internal geometries) and not the alteration of the DNA levels must be responsible for the heritable change in the plant, and must result in what is inescapably characterized as a new, distinct genotype.

Although the above results mitigate against it (because of the increase in DNA for the S plant under decreased energy-warmth conditions), it might still be argued that the original inductive events simply reflect a changed energy-throughput for the developing plants that permanently alters the bioenergetics. Further, this changed energy-throughput could account for the increased weight of the L-induction correlating to the increased DNA of the L type, and the decreased weight of the S types correlating to its diminished DNA values — even if the DNA changes were less permanent.

Experiments with another variety of flax, Lyral Prince, refute this argument. The DNA value for the induced L type of Lyral Prince is 95.3 units; for S, 86.3 units; and for Pl 90.5 units — but L weighs 73.5, S 23.6, and Pl 16.5. That is, the Lyral Prince induction experiments resulted in reproducible changes, but the changes differed from those of the Stormont Cirrus in that L is larger than S which is larger than Pl with regard to weight characteristics, even though L is larger than Pl which is larger that S with regard to DNA content per cell.

These results argue against the idea that the inducing conditions cause the heritable changes in the plant sizes and that the accompanying DNA changes only *reflect* the altered bioenergetics of the plant changes. Instead these results point to fundamental alterations in the overall physiological and biochemical relationships that bear no resemblance to simple quantitative changes that somehow become reified into the cell's hereditary mechanism.

In answer to the final question posed earlier, experiments that could give insight into the types of DNA (that is, repetitive or single-copy DNA, or DNA that codes for messenger or transfer RNA) were equivocal and thus unhelpful at this point. In such experiments, the number of gene copies of one particular gene coded for by the flax DNA, that of ribosomal DNA, was found to be increased in the L plants such that L has about 70 percent more sequences coding for DNA than does S. However, the amount of material necessary to code for this gene is very small compared to the total genomic material; thus the differences in rRNA genes accounted for only .23 percent of the difference between the two plant types. This increased rDNA finding is not surprising since ribosomal material is directly associated with increased cell metabolism. Further experiments looking into the increased presence of this gene after L-DNA reverts to Pl levels are not yet reported on.

It is obvious that this last group of experiments, based on the patently incorrect reductionist assumptions of molecular genetics, will not provide the insight necessary to account for the fundamental nature of the transformations demonstrated in the flax experiments.

Negentropy

The overriding feature of all biological phenomena is that they do not reflect a situation of equilibrium.* Indeed, whether one examines evolution or embryology, it is immediately apparent that the results reflect situations of qualitatively increased energy throughputs. Evolution thus actually represents the universal process of self-development, whereby changes of various individual parameters within the whole contribute to and form the bases of *purposeful* changes for the whole.

> The system of life fundamentally represents a world line of negentropy....What is primary is the negentropy of the ecology which, as this value advances through the participating development of the species, creates the material (thermodynamic) basis for the advancement of species....
> (LaRouche 1975, p. 172)

Any society, using its given resource base and concomitant technologies, modes of relationships, and so forth that are characteristic of its given state of development not only reproduces itself in a mirror-like manner, but by generating energy above that necessary for that simple reproduction, the society derives free energy and thus creates the preconditions for transformation to a higher-order society. In turn, higher-order society is characterized by new energy sources, new technologies, and new relationships that redefine the particularities into new beings. In human societies for example, parents not only ensure that their children reach the skill and cultural level that was necessary for the parents to utilize the resource base of the society's existence; they also use the free energy generated in their society's mode of existence to advance the quality of the individuals, including their children, within that society. This advanced quality is realized in the form of increased wealth, both material and cultural, and increased energy throughputs, leading to conditions for qualitative breakthroughs characterized by new sets of societal relationships, resources, and so forth. As LaRouche points out, "The measure of the productive power of labor is the *increase* in the productive power of labor." (1975)

This type of transformation is an absolutely necessary one. In actuality, any society is based upon the utilization of resources that ultimately are finite. The exhaustion of that resource base prior to the qualitative transformation to a new, increased energy-density throughput modality of necessity must result in the collapse of that society and a reversion to lower forms.

Simple Extended Reproduction

Any given evolutionary epoch is characterized by a given resource base — certain bioenergetic capabilities with specific complexities and derived values (that is, "technologies") that determine the content of life forms, their ecological niches, and their interrelationships for the biosphere as a whole. During any given phase of the evolving biosphere, simple, extended reproduction takes place — the expansion of populations and of life forms coherent with this modality. The bioenergetic capabilities of the most advanced life forms define and delimit the modality. (Most advanced here means that which has the highest energy-density throughput and which historically has evolved to form the basis of the supersession from the previous, more limited resource base.)

Those transformations *superficially* embodied in the Darwinian explantions occur during this period of simple extended reproduction.** That is, there is a constant shifting of populations, a linear, quantitative change in populations and species, that tends toward the perfection of the utilization of the given modality. But these processes are insufficient to account for the progressive evolution of the biosphere.

As this perfection is realized, the energy throughput for the entire ecology (biosphere) increases, and the energy-density approaches a maximum for that given modality. At this time certain *qualitative* events must occur: processes that were marginal to the effectiveness of utilization of that modality must assume a crucial transforming quality to supersede the delimited resource base upon which the given modality rests.

*For a full discussion of negentropy, see LaRouche (1975).

**The term superficial is used because even this is not a situation of equilibrium but rather a situation of an expansion and modification, albeit quantitative, of the biosphere.

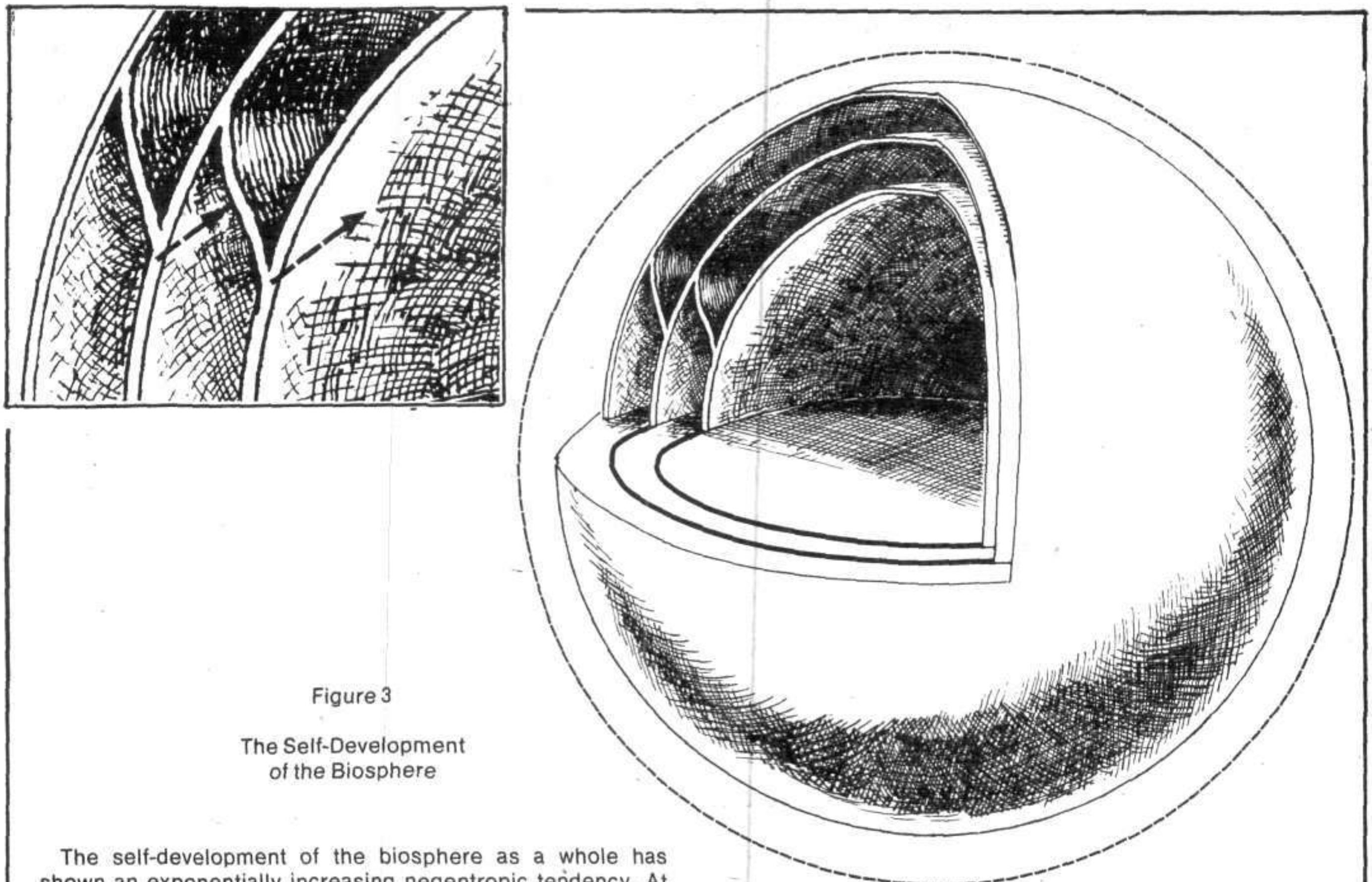


Figure 3

The Self-Development of the Biosphere

The self-development of the biosphere as a whole has shown an exponentially increasing negentropic tendency. At every branch point, however, there is a possibility of ecological holocaust — a collapse to a *lower-order manifold.* This drawing heuristically depicts this exponential development and the possibility for regression at each crisis point (Inset).

For any given period during the continuous process of the biosphere's self-development, there is a characteristic and unique set of relationships determined by the interaction lawful for that period or manifold. This is realized thermodynamically by the period's delimiting energy-density throughput levels and capability for increased energy differentiation. The perfection of the utilization of the particular energy-density, ironically, hastens the exhaustion of that mode; for each manifold is predicated on a given set of resources. At the crisis point, the nonlinear quality of interaction present in each mode must realize a transformation to a new, higher-order manifold. As the existing lawfulness becomes less stable, forces previously marginal begin to assume a hegemony that forms the basis of the transformation to the superseding manifold.

To take the present period as an example, the increasing scarcity of resources demands the transition of the biosphere to the next higher manifold — a fusion-based economy. The individuals who recognize this necessity — currently marginal forces — bear the *responsibility* for the determination of this transformation.

If not, there must be a collapse as the useful energy throughput diminishes in response to the now-real shortage of resources.

To say this in a slightly different manner: as energy-density throughputs are maximized, reaching a peak of intensity, (an intensity which peaks as the defined resources begin to become marginal), the ecology must respond with a qualitative transformation to a new mode that is sustained at higher bioenergetic levels. Without this transformation an energy crisis will rapidly ensue, a crisis that becomes real if a new resource base has not been *created* to provide an increased energy-density throughput for the *entire* ecology.*

At this conjuncture — when the energy density throughput reaches a maximum for the given modality and the finite quality of the resource base of that modality is apparent — the realization of the qualitative processes of evolution becomes mandatory.

*It is obvious that the generation and subsequent utilization of free energy provides the basis for the crucial transformation to the superseding modality. If a society sees the impending energy crisis and begins to conserve energy, cutting back on the generation of free energy, it destroys the possibility of its realizing that transformation. It is as though the society would seal itself in a coffin in which it cannibalizes itself before acceding to lower, less advanced modalities. These less advanced levels are even less capable of generating the free energy necessary for the transformations necessary for the continuance of life forms. Thus the idea of energy conservation is a sure formula for a downward spiral for the ecology as a whole — the opposite of the effect promised by the arguments of the zero-growthers.

During these conjunctural periods where qualitative shifts are demanded, previously marginal processes become hegemonic; that is, marginal processes that incorporate new *geometric relationships* become the fundamental determining aspects of the incipient higher modality, via *nonlinear* transformations. These processes define the new resource base, the new bioenergetic relationships that assume a global hegemony and set the stage for a new, greatly expanded epoch of simple extended reproduction. (See Figure 3)

By the terms qualitative and nonlinear I am explicitly stating that the lawful properties encompassed in a given set of relationships of a particular modality will no longer be valid as the succeeding order of relationships becomes hegemonic. This means, implicitly, that while predictive assertions can be made for phenomena within a given modality, one cannot predict phenomena that reflect the lawfulness of the relations that will exist in the new modality.

Darwinian Evolution

It should be obvious from the above discussion that phenomena that reflect situations of equilibrium are relatively insignificant in a qualitatively evolving biosphere. Nevertheless, since Darwin became hegemonic in the nineteenth century, biologists have viewed evolution as an essentially equilibrium phenomenon based upon a random process where no higher-order lawfulness exists. Vigorously negating any positive tendencies which might impart a direction to evolution, today's leading biologists insist that the process of evolution is "value-free," "blind," and "mechanical." For them "natural selection is the determinant of what exists as a purely statistical force blindly directing the ever-changing panorama of the living world."*

This rubbish is scientifically unjustifiable, but it has served to justify zero-growth ideologies that find their realization in fascist political forms, to reify reductionism in the biological and related sciences, and to protect the long-standing fallacy that the universe is entropic and at best approaches an equilibrium or steady-state condition on earth.

Briefly stated, the biological view of the molecular mechanisms of evolution is as follows: The carrier of the genetic code, DNA, consists basically of a linear array of discrete genes, an informational tape that functions as a computer-like biofeedback system (and, therefore, does not reflect any higher-order interactions). In this context evolution reflects the accumulation of a variety of random mutations in the genetic material and of certain recombinations within the linear molecule that lead to a *quantitatively* new genotype that is expressed as a different phenotype (individual organism) in the population. Over a long period, these mutations accumulate in the population's gene pool such that an incipient species exists which, if it is reproductively more successful under the competitive pressures of natural selection in a world of limited resources, will become the predominant form.

To elaborate this more fully: Mendel's discoveries were that genes, discrete particles of hereditary material passed on from one generation to the next, were responsible for the realization of observable, expressed phenotypic traits such as flower color, seed texture, blood type, and so forth. Mendel demonstrated that these phenotypic traits could be passed from generation to generation in a lawful, predictable manner. Based in a statistical approach that has since grown to a subdiscipline in its own right, these experiments demonstrated that the genes responsible for particular traits are more or less independent of one another (that is, have a discrete quality).

Mendel's discoveries, not appreciated until 1900, were quickly supplemented by other investigators who showed that chromosomes are the structures that carry the hereditary traits. Those phenotypic traits most likely to be transmitted at the same time to a single offspring were shown to have their genes for those traits on a single chromosome and were considered to be linked; those traits less likely to be transmitted at the same time to a given offspring were shown to have their genetic material on different chromosomes.

Beads On A String

Growing out of these experiments and the many others that have since followed is a viewpoint that permeates all biology today, namely, that chromosomes are linear arrays of genes, some in clusters and some single, analogous to beads on a string. Biologists often will go to great lengths to deny that the beads-on-a-string idea is fundamental to genetics, citing translocations, inversions, and other various position effects of chromosome behavior. However, all evolutionary theory, all molecular genetics experiments — with a very few notable exceptions — if traced back to their underlying assumptions, view genes as discrete particles as much as physicists view atoms or quarks as things in and of themselves.

Further experimental work demonstrated that there is a direct correlation between the linear sequence of moieties for a given DNA molecule and the resultant protein for which the DNA codes. (See Figure 4) The sequence of the components of DNA for a particular gene provides the template for the sequence of the linked components (the amino acids) that make up the corresponding protein. A change in one of the components of the DNA sequence usually produces a change in the sequence in the corresponding components of the protein chain, resulting in an altered protein molecule.

Molecular geneticists believe that this process of mutation (a change in one of the "letters" of the DNA molecule) forms the physical basis for evolution. As a result of *random* changes in the base sequence of DNA which are then translated into altered protein molecules, new capabilities are genetically generated for the phenotypic repertoire of the offspring (for example, albinism, the lack of skin pigment, in some individuals). Although mutations are held to be detrimental to an organism and therefore rapidly declared unfit by the force of natural selection and weeded out, some mutations lend a reproductive advantage to the organism, and these mutations subsequently accumulate in the genetic pool

* The capitulation of biology to this mechanistic nonunderstanding has destroyed the biologists' ability to see any universal lawfulness in biological existence. One would think that the continued study of biologic phenomena, negentropic in its very being, would command the biologist to muster the hubris to demand that scientists in other disciplines seek to understand this negentropic lawfulness inherent in their studies. Alas, the biologists' subservience to the "hard" science of mathematics, physics, chemistry, has instead resulted in *apologies* for the lack of coherence of biological processes with the other phenomena. "Life is a constant struggle against the tendency to produce entropy by irreversible processes. The synthesis of large and information-rich macromolecules, the formation of intricately structured cells, the development of organization — all these are powerful anti-entropic forces. But since there is no possibility of escaping the entropic doom imposed on all natural phenomena under the Second Law of Thermodynamics, living organisms choose the least evil — they produce entropy at a minimal rate by maintaining a steady-state." (Lehninger 1965)

of the population. Natural selection and related forces are thus the sole judges of the value of these events, and as such are believed to provide the basis for evolutionary change.

An example of how biologists use this schema is found in studies on variations among species for a particular family of proteins, such as the cytochromes. Cytochromes are crucial in the bioenergetic transformations in higher organisms, and therefore they are not likely to be eliminated over time. They are found to differ very little in their (linear) amino acid makeup among closely related species (those whose divergence from a common ancestor is relatively recent in time), but the differences are substantial for more distantly related species. The biologists reason that in the general process of random mutation — which is supposedly statistically constant over time — variations in the cytochromes reflecting the DNA variations can be expected to appear at a fairly constant rate. Since species that are highly divergent have had more time to accumulate these variations (the supposed basis for their divergence) they therefore will show greater differences in the amino acid sequences of these proteins. Analysis of these molecules does show these differences to increase over time in a fairly linear fashion, although even in this favorite example there are discrepancies which are not readily accounted for.

It is apparent in this scheme of evolution that although these changes do result in transformations in which speciation occurs (and which have been empirically documented, as in the cytochromes), the transformations at best are quantitative and linear. In other words, the biologists' mechanistic scheme of evolution is accurate for accounting purposes as a process of a simple quantitative extension of relationships *within* a given ecological modality — *but this is not evolution.*

In this accounting-type scheme, to take a graphic example, extensive comparisons between the proteins of humans and chimps show that these proteins differ only slightly. Now are these species equally closely related to gorillas, orangutans, and gibbons (as the protein comparisons say that they are) or do the qualitative differences between humans and chimps indicate that fundamental or critical evolutionary processes are not a reflection of linear quantitative steps but are based in qualitative transformations that necessarily reflect the negentropic invariant of the self-developing universe?

A quick glance at other areas of evolution point out the same dilemma for these accountant-evolutionists. For one to hold that evolution is a cumulative quantitative process it is necessary that the data verify this view. Specifically, there should be a record of a continuous change in the fossil record, one that demonstrates the step-by-step transition of species transformations and divergences. Instead the fossil record is characterized throughout with gaps, where the changes that occurred were obviously too rapid and too qualitative to be accounted for by the current linear model. For example the transition from cold-blooded to warm-blooded organisms is difficult to explain in a linearly incremental manner. Indeed, only with an understanding of the *necessity* for the biosphere to expand to a higher order, that is, to a level of increased energy-density throughput for the *total* ecology, can one begin to comprehend the process that embodies the *nonlinearity of a transformation* like that from cold-bloodedness to warm-bloodedness.

The Relevance of the Flax Experiments

At this point the crucial nature of the flax experiments becomes apparent. The speciation tendencies embodied in this transformation specifically contradict the evolutionary *hypotheses* postulated by molecular geneticists. There is no selection from a genetic pool that alters gene frequencies in a population; rather, there is a generation or transformation to a self-stabilizing phenotype, which assumes the role of a new genotype. This concept flips Darwinian evolution on its head: In actuality the individual directly responds to the environment in such a way as to effect a rapid, heritable transformation to that individual's progeny. In turn, via an altered energy throughput capability, this transformation qualitatively alters the ecology, and as this alteration becomes ramified throughout for the ecology, it sets the preconditions and necessity for further qualitative transformations.*

In fact, the generation of a new genotype by a qualitative transformation that occurs in response to a specific environmental stimulus is clearly demonstrated. This transformation is global in the sense that it is not the introduction of a monster that bears little resemblance to its parents; it reflects a coherent change for the plant as a whole and for the ecology as a whole. This type of transformation is representative of those changes that effect an extension of energy throughputs within a given evolutionary mode. I emphasize here that those changes that will be responsible for the qualitative expansion of the biosphere are now under human hegemony.

As the flax experiments clearly demonstrate, the basis of the transformations is the energy throughput for the developing plant. Although the effects of varied fertilizer components allowed no conclusions, the single variable that promoted the transformations was the placement of the seedlings in the greenhouse during the critical developmental period. Experiments that showed no differences between various fertilizers showed a very specific induction response to increased greenhouse temperatures. Indeed, for any of the transformations to occur, according to Durrant, "all that is required of the general inducing environment is that it promotes rapid, healthy growth;" the specific fertilizer is responsible for the particular direction the induction takes. (1972)

On the molecular level, it is obvious that the changes in the flax plants do not reflect the results of a long-term accumulation of mutations. What must be happening is that the increased bioenergetic throughput of the inducing conditions causes a change in the internal (geometric) relationships, by which the cell realizes its developmental potentialities, to a manifestly new array. This then becomes reified into the genetic material for the conservation of these new potentialities.

The basic question these experiments immediately raise concerns the nature of genetic material. Although, as some investigators point out, the hereditary makeup of a cell does not reside exclusively in its DNA, there is a highly specific quality to this double-stranded helical molecule that is of fundamental importance to all biological phenomena, from evolution to thought. (See Figure 4.)

DNA

Bacteria respond to the presence of a specific nutrient by producing a specific set of enzymes. Elaborate and clever experiments, originally done by F. Jacob and J. Monod and since expanded by many others, have elucidated the means by which this occurs: The nutrient combines with a specific protein, the repressor, that was bound to a particular part of

*In light of these and other similar results, it is apparent that Lysenko's early work, although held in total disrepute, warrants further investigation.

the bacterial chromosome and rendered it inactive. This causes the repressor to be released from the (chromosomal) DNA, and "frees" the DNA to be transcribed by the actions of other cell constituents. This transcribed set of genes (an operon) contains the instructions for the making of those enzymes (proteins) that will digest the nutrient. When the nutrient is no longer present, the repressor, no longer combined with nutrient, reattaches itself to the specific part of the DNA. This turns off the operon, and the enzymes that were made for the digestion of the nutrient are no longer synthesized. This "on-off" mechanism, with some variations, is the picture implanted in the minds of all molecular biologists today. Although the model is empirically demonstrated to be true in this case and for a few other cases, it is obviously inadequate for explaining any higher-order interactions.

To look at one such higher order interaction, the chromosomes of eucaryotic cells differ from those of the lower-order procaryotic cells in several important ways. Associated with these higher-order chromosomes are many different proteinaceous molecules, whose relationship to the DNA only now is beginning to be elucidated. Unfortunately, the vast majority of approaches to this phenomenon look at these proteins as fulfilling the role of the repressor molecules, thereby reifying the reductionist off-on, beads-on-a-string model. Another unique quality of the eucaryotic DNA is that it contains many short sequences that are reiterated many times throughout the length of the chromosome. Again, while this unique quality must confer a qualitative difference to the eucaryotic chromosome, most molecular biologists are looking to these sequences as "control points" for coordinating sets of genes for off-on switching, thus linearly extending the bacterial findings to higher order phenomena (See Fig. 5).

Additionally, the amount of DNA per cell in eucaryotes is many orders of magnitude greater than that found in procaryotes, coherent with the general tendency of increased

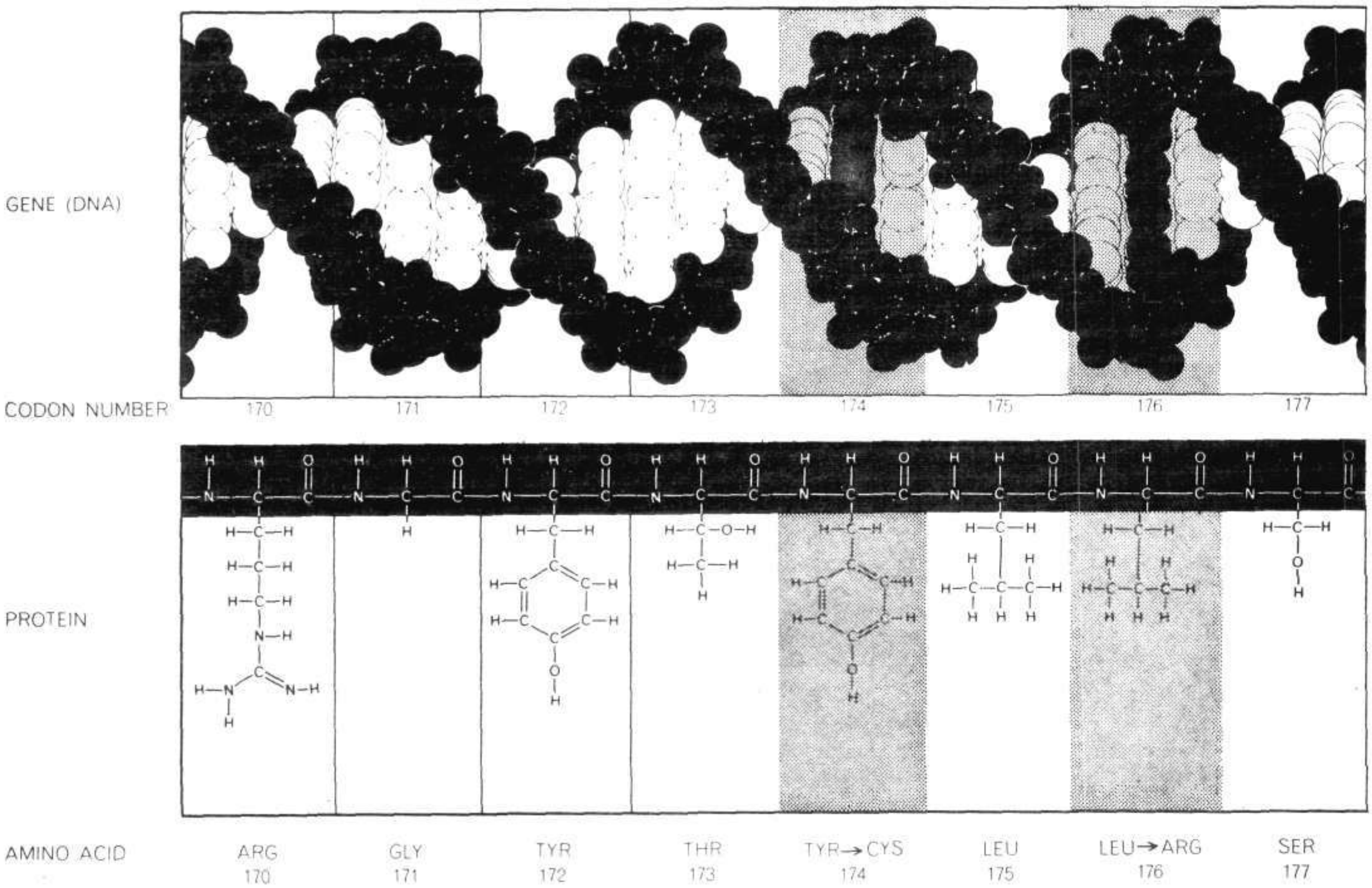


FIGURE 4
The linear correspondence of DNA to protein

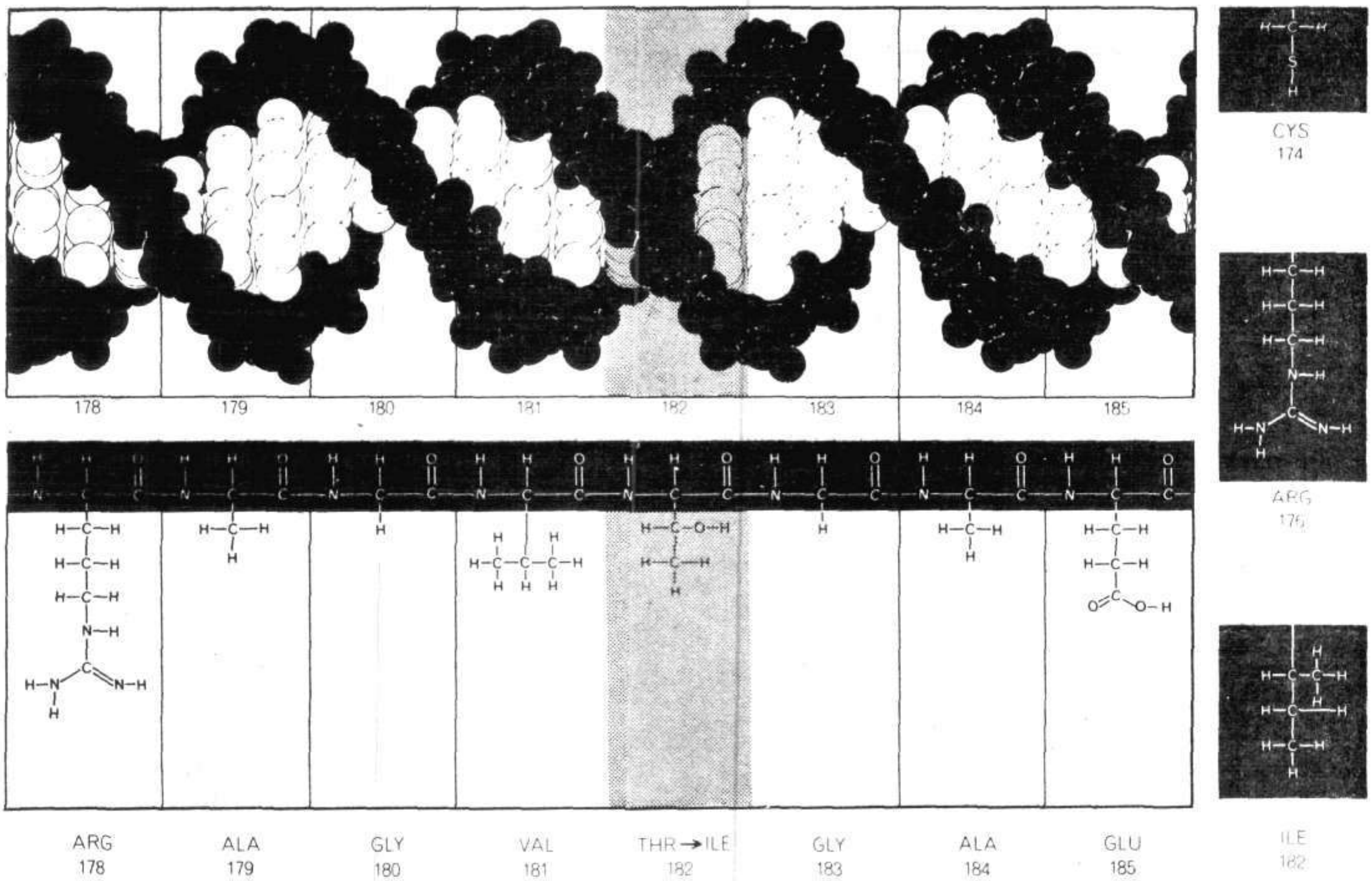
Structures of gene and protein have been shown to bear a direct linear correspondence. It has been demonstrated that a particular sequence of coding units (codons) in the genetic molecule deoxyribonucleic acid, or DNA, (top), specifies a corresponding sequence of amino acid units in the structure of a protein molecule (bottom).

In the DNA molecule depicted here, the black spheres represent repeating units of deoxyribose sugar and phosphate, which form the helical backbones of the two-strand molecule. The white spheres connecting the two strands represent complementary pairs of the four kinds of base that provide the "letters" in which the genetic message is written. A se-

DNA per cell in evolutionary progression. It is argued that the increased bits of information represented by the increased DNA (in the form of more control points and genes which code for protein molecules) results in a greater metabolic repertoire sufficient to account for the differences as great as those between eucaryotes and procaryotes. (In fact, it has been calculated that the number of bits of information the genes represent falls substantially short of the information required to model the metabolic and geometric parameters of cells, at least in terms of computer capabilities.)

The final difference, and one that indicates the area deserving the greatest attention, is the multitude of structural formations that the eucaryotic genome can assume. While the primary (linear sequence) structures and the secondary (coiling) structures have similar features for procaryotic and eucaryotic DNAs, the higher order tertiary and quaternary structural features of the eucaryotic chromosomes suggest the unique capacities for the behavior of these cells. It is here that statements on the qualitative nature of evolutionary change and its relationship to DNA hold the greatest promise for further investigation. Woese has pointed out that the triplet code of m-RNA, interacting with the multicomponent ribosome, works by creating a field, and that the field interaction assures the fidelity of the translation process. (1977) In other words, it is not just the triplet code of the m-RNA matching through hydrogen-bonding with its complement triplet of the corresponding t-RNA that is the basis of translation; rather, translation depends upon higher-order interactions that utilize field effects for their effective processing of genetic information.

The higher-order processes on which the flax experiments and other evolutionary and embryological phenomena depend similarly must be mediated through the multipotential macromolecules of the cell, most specifically through the DNA. The complex of structures the DNA can assume must,



quence of three bases attached to one strand of DNA is a codon and specifies one amino acid.

The amino acid sequence illustrated here is the region from position 170 through 185 in the A protein of the enzyme tryptophan synthetase produced by the bacterium Escherichia coli. It was found that mutations of the *A* gene of *E. coli* altered the amino acids at three places (174, 176, and 182) in this region of the *A* protein.

The three amino acids that replace the three normal ones as a result of mutation are shown at the extreme right. Each replacement is produced by a mutation at one site (dark shading) in the DNA of the *A gene.*

Source: Scientific American (1967)

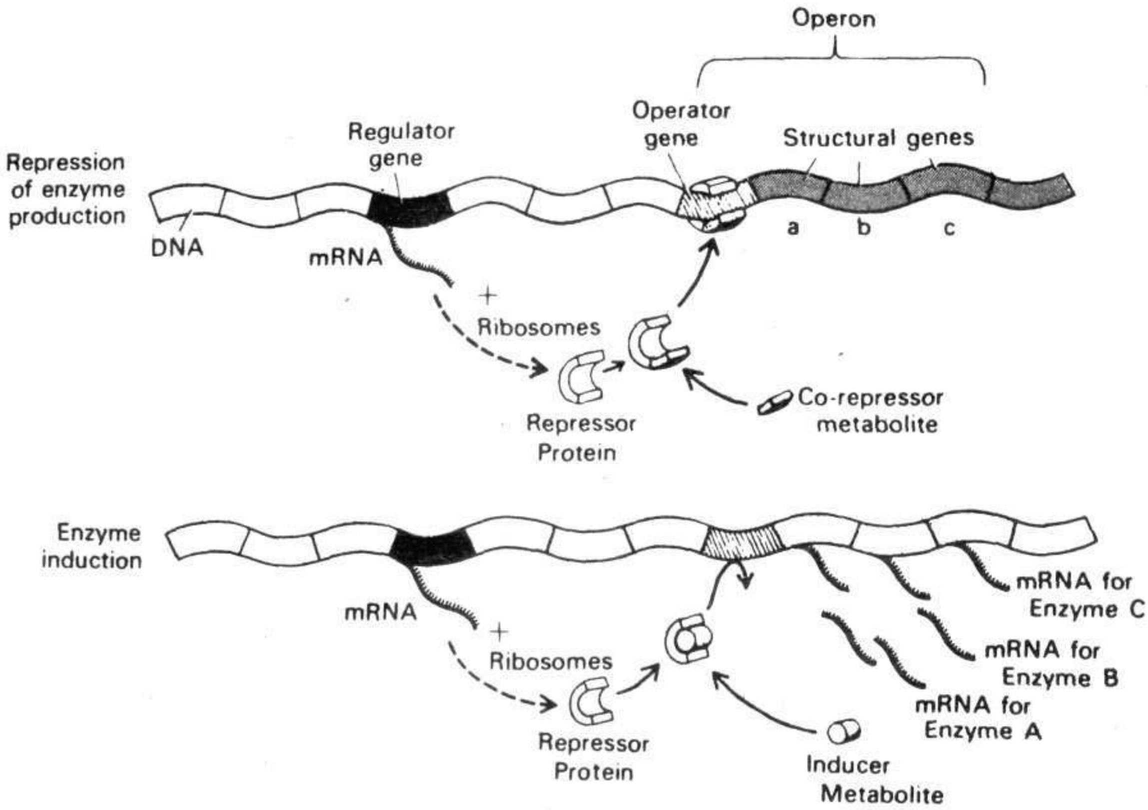


FIGURE 5
The Operon Concept

According to the operon concept of gene control, a regulator gene occupying one site on the DNA strand controls the production of a repressor protein which, in combination with a co-repressor substance, inhibits the activity of an operator gene on another site of the DNA strand. In the presence of an inducer compound (that is the nutirent to be digested), the repressor protein is unable to block the operator site. This operator gene controls the activity of adjacent structural genes on which there is an assembly of messenger RNA (m RNA) molecules involved in manufacture of those enzymes used to digest the nutrient.

through field phenomena, create geometries of physiological relationships that determine the cellular activities and further potentialities. The qualitatively expanded potentiality of the eucaryotic chromosome must have the capacity for sensitivity to altered geometries that reflect altered relationships. This expanded sensitivity is *necessitated* by the increased richness of the geometric relationships of the eurcaryotic cells, demonstrated by their vastly increased energy throughputs, their increased internal complexities and differentiations, and their extensive morphologic potential.

This genetic sensitivity must account for the phenomena demonstrated by the flax experiments — direct, specific, and reproducible effects of environment on phenotypic and genotypic expression, and the qualitative alteration of the genetic makeup of the organism that reflects neither mutational alteration nor currently postulated genetic control mechanisms.

The implications here for epigenetic developmental, as well as evolutionary phenomena, are readily apparent. As the developing organism reflects an altering, self-developing ecology (or embryonic environment) for the particular cells within the organism (embryo), the qualitative nature of the genetic material must undergo alteration without undergoing mutation or repression-induction of particular genes or sets of genes. Indeed, the meaning of the particulate genes would be subsumed under the field of the total cellular hereditary array, including the overall cellular metabolic physiological relationships. The flax experiments vigorously testify to this.*

Of course, the code, base-pairing relationships are not meaningless; rather, these experiments indicate that the particulate aspect of the DNA genophore is subsumed under a higher-order lawfulness, whereby the alteration of the geometries of the macromolecular and organellar relationships direct the process of the cells' metabolic and phenotypic (and implicitly genotypic) transformation. Additionally, the new geometry of the cells' hereditary makeup must be

* The process might be considered analogous to particle-field phenomena in plasmas when altered (enhanced) energy flown into the "cell" of the plasma changes the essence of the discrete materials and creates the condition of a self-developing reorganization.

a reflection and reification of the incipient relationships of the biosphere.

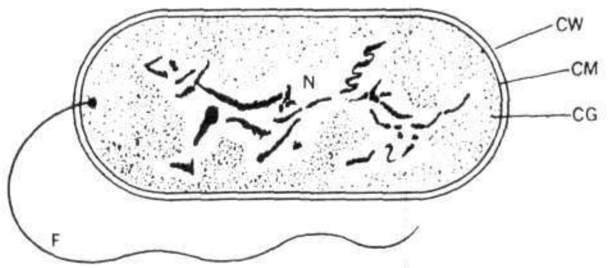
Negentropy — The Starting Point For Research

The history of human cultural evolution and of biological evolution, as well as the findings on the flax plant, are all consistent with the fact that the universe is negentropic. The invariant condition for continued societal and biological existence is a nonlinearly expanding energy-density throughput — not equilibrium.

The flax findings, which are at odds with contemporary biological theories, are a crucial experiment that demonstrates the inadequacy of these theories in accounting for the fundamental nonlinear transformations in ecologies. Furthermore, they provide a conceptual basis for the rethinking of the nature of the constituents of the cell and their relationship to altering geometries of the ecology.

The negentropic invariant must be the starting point for all scientific research; the conceptual framework that guides the researcher must be consistent with the nonlinear, nonequilibrium phenomenology that is the condition for breakthroughs in all biological phenomena. Just as in the fusion effort, where fundamental plama research must take place to ensure the successful realization of a fusion-based economy, biological research must focus on higher-order interactions that result in qualitative alterations in the relationship of the individual to its total ecology. This will ensure necessary breakthroughs in fundamental biological questions in agriculture and human health and provide a fundamental understanding of nonlinearity that is necessary for progress in all scientific endeavors.

FIGURE 6



Above: Procaryotic cell

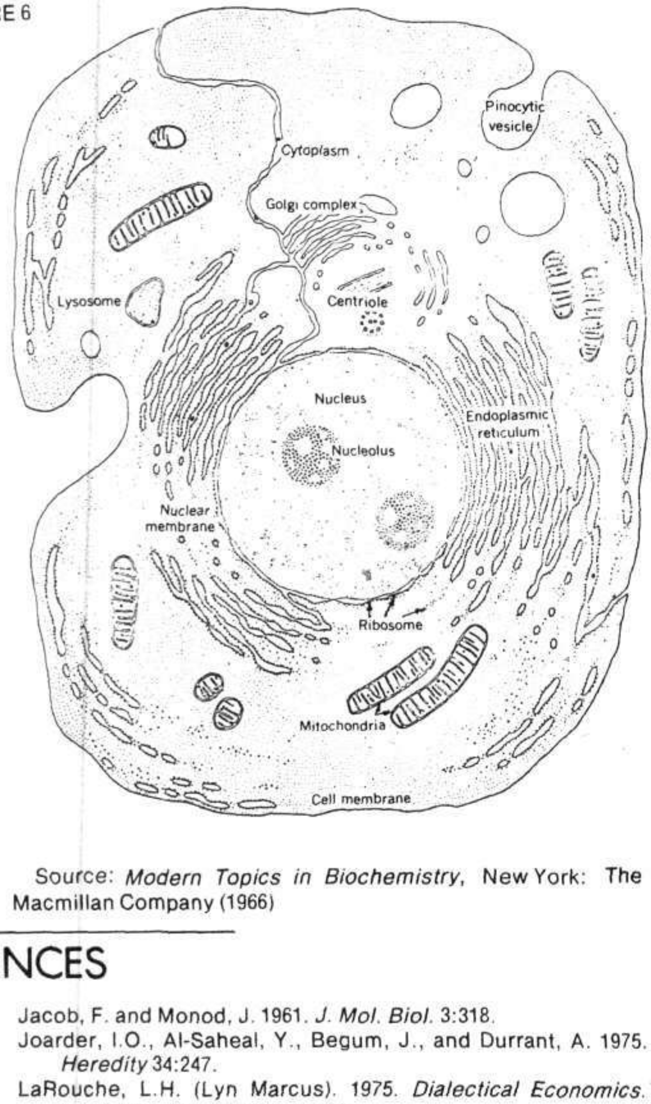
Diagram of a longitudinal section through a bacillus (bacterial cell) showing cell wall (CW); cytoplasmic membrane (CM); cytoplasmic granules (CG) — primarily ribosomes; the ramifying nuclear region (N); and the flagellum (F).

Right: Eucaryotic cell

A generalized animal cell based on what is seen in electron micrographs. The mitochondria are the sites of the oxidative reactions that provide the cell with energy. The dots that line the endoplasmic reticulum are ribosomes, the sites of protein synthesis. In cell division the pair of centrioles, one shown in longitudinal section (rods), other in cross-section (circles), part to form poles of the apparatus that separates two duplicate sets of chromosomes.

Note that the organelles in the eucaryotic cell are membrane-bound, each providing its components — including the DNA containing nucleus — with specific and unique conditions. This results in a highly internally differentiated condition where efficiencies of reactions are greatly increased.

The size differences between the eucaryotic and procaryotic cells are very pronounced: For a 1 micron diameter bacterium and a 10 micron diameter animal cell, the volume differences are 1,000-fold. The energy throughput differences are even greater.



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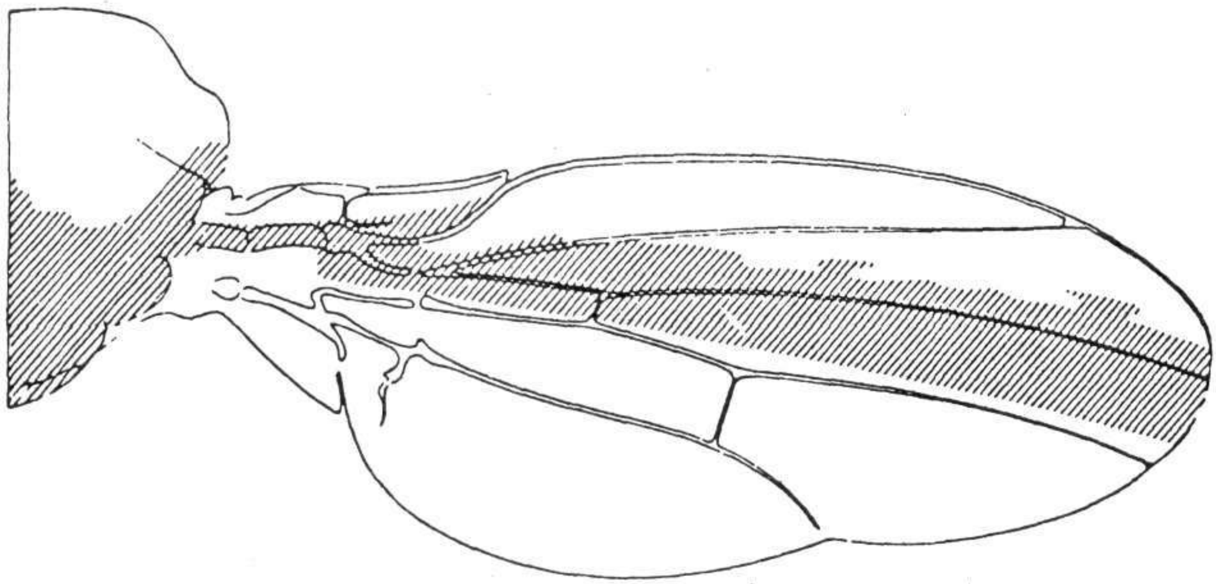


FIGURE 1
Mature Fruit Fly Wing

In the "imaginal disc" which forms the wing, the marking of a single cell permitted researchers to trace its descendant cells or clone into the adult wing. The clone's shape implies a border line on the surface of the wing, over which no cell in the clone will cross — even though there is no obviously visible structure corresponding to this line.

Drosophila Embryology— The Dynamics of Evolution

Ned Rosinsky, M.D.

A series of recent discoveries in embryology have opened the way for an elaboration of a rigorous science of biology founded solidly on the principle of a self-developing biosphere. The relevant findings consist of a class of field types of interactive phenomena in the early developmental stages of advanced types of insects, including butterflies, bees, and here under consideration, the common fruit fly (*Drosophila melanogaster*).

A group of flat, disc-shaped structures composed of cells, call "imaginal discs," arise in the embryo of the common fruit fly and then go on to differentiate into the various parts of the adult fly, such as the wings, legs, antennae, genitalia, and parts of the thorax and abdomen.

The stage of this process in focus here is an early functional subdivision of each disc, which carries through to the adult structure. The geometry of this subdivision is different for each kind of disc that produces a different adult structure, and conforms to the geometry of a global oscillation system on a two dimensional surface whose boundary is shaped like that of the disc.

While the explicit physiology responsible for this oscillation system has not yet been discovered, this pattern could result from a number of relatively simple chemical processes, such as the production of two substances over the disc surface, each of which affects the reaction rate of the production of the other. This would result in a see-sawing of concentrations, or oscillations, that depend on the shape of the boundary of the disc.

These disc-like structures exhibit an oscillating behavior in the course of their development whose geometry is not only central to the development of the organism, but suggests a powerful dynamic by which the organism could undergo rapid evolutionary change. There is good evidence for a relationship between changes in the disc geometries and changes in the structure of the corresponding adult organs; these structures might function as powerful systems of amplification of even marginal genetic changes — to the extent of successively reordering the entire morphology in a coordinated way.

If that is the case, these are the first findings in the actual physiological of embryological development that cohere with the manifest (and necessary) capacity of the biosphere to undergo qualitative "jumps" in evolution.

Even on the gross descriptive level, the growth of an embryo is a multi-stage process of "unfolding" that must be seen in terms of primary self-development. Theories of the lawful ordering of stages, each built upon the conditions provided by the previous stages, have been advanced for more than 200 years under the general term "epigenesis," but the chief failing of all such theories and their various interpretations of experimental data is that they do not proceed from a concept of the primacy of evolution. They miss the most important aspects of the material under study, the capacity for further evolution inherent in biological processes. This implication for evolutionary capacities is the fundamental importance of the specific findings of embryology described here.

The *Drosophila* discoveries themselves, ironically, have been predominantly the work of researchers whose initial training was in physics, and who looked at previously known biological data and noticed by simple inspection certain overall patterns suggestive of the type of "field" phenomena common in oscillating electrical and fluid systems. They then worked out the mathematics for an oscillating system the shape of the *Drosophila* "imaginal disc," and found it closely corresponded to the actual *drosophila* data.

A complex structure can be understood only if it is seen as arising lawfully as a necessary part of the critical determinants of evolution at the time of its historical inception. At a later point in evolution, such a mode may be subsumed as a secondary or tertiary aspect of a new, dominant mode, but it can never be adequately understood from that perspective. Thus, the embryological disc of the fruit fly is incomprehensible if studied in isolation from the fruit fly (the usual reductionist method). It is also incomprehensible if studied in the usual "interactionist" sense as merely part of a functioning organism. Our working hypothesis must be that such complex structures, understood generically, were each at some point a critical breakthrough for biospheric evolution, and that to study them requries putting their structures in the context of evolution of the earth as a whole.

We should here make the qualitative distinction between a mode arising as the critical determinant of evolution at a crisis point, and a mode arising as subsumed within the continuing dominance of another mode. We do not know which is the case for the *Drosophila* imaginal disc. The critical point is that this distinction must be decided empirically in studying any given mode.

Although we focus on the fruit fly, there is evidence that the general systems described here also function in a wide range of other types of organisms, including the vertebrates and including man. In higher organisms these modes are subsumed under much more powerful modes, for example, the determination of the biosphere at this point by man's deliberate, evolutionary social practice.

From such considerations we can predict that living systems function with a high order of interconnectedness such that even marginal changes, as in slight alterations of the genetic material, would manifest themselves not only as large shifts but as *coordinated shifts* in the organism's overall morphology and physiology, consonant with "jumps" in the ecology's development. The *Drosophila* wing-disc results are the first demonstration of an initial coherence with this principle in embryology.

The Drosophila Wing-Disc

The fruit fly embryo begins as a fertilized egg that goes through a number of cell divisions until a hollow ball of cells (the blastomere stage) is produced. On the inner surface of this hollow ball some cells then protrude inward, separate off, and eventually grow into a set of 19 disc-shaped structures, each disc being approximately two cells thick but thousands of cells across in the other dimensions (thus approximating a two-dimensional structure). Some of the discs are roughly circular, some oval, others more asymmetrically shaped. As the insect nears maturity, the cells of these discs undergo final differentiation into the various adult structures, each different structure being produced by a disc of a characteristicly different shape.

The wing-forming disc (ham-hock shaped) has been most thoroughly studied. By doing marker studies on individual cells in the disc, it has been possible to trace all of a cell's descendant cells, called its clone, into the mature wing. It has been found that each cell's clone generally forms an irregularly shaped patch of cells on the wing. Its place on the wing depends on the position the cell originally occupied on the imaginal disc.

In the course of the tests, a striking pattern was found in the arrangement of the clones on the wing. There is a specific demarcation "line" on the adult wing surface over which the clones on either side will never cross, even though a clone may run along the line for hundreds of cells. (See Figure 1) Tracing such a "line" of demarcation on the wing back to the disc, it is possible to establish an equivalent line for the cells on the disc. Again, this is not a physical border, but functional only in terms of the inability of progeny of a cell on one side of the line to cross to the other side.

If the cells of the disc are marked at a certain early age of the embryo, then only the one demarcation line will be found on the wing. However, marking of cells at later ages shows that more lines occur, and occur in a definite sequence as the disc grows. These lines form a final pattern which is unique for each type of disc, that is, the wing-forming disc, the leg-forming disc, etc.; but for the same type of disc, such as the two wing discs, the pattern is always the same, and turns out to be a direct function of the shape of the disc. The wing disc pattern is shown in Figure 3.

It was this pattern, found by earlier investigators, that originally suggested to Kenneth Trabert, who is both a physics PhD and MD, that the phenomenon was mathematically related to an oscillating or "vibrating" type of activity. For example, if the disc shape in Figure 3 was a slightly distorted drum head, then the vibration of such a drum would produce standing waves, or overtones, whose nodal lines would correspond generally to the pattern of the disc lines. (Compare the two dimensional drum surface to a one dimensional vibrating string. The nodal points on the string which arise with the overtones correspond to nodal lines on the vibrating drum surface.)

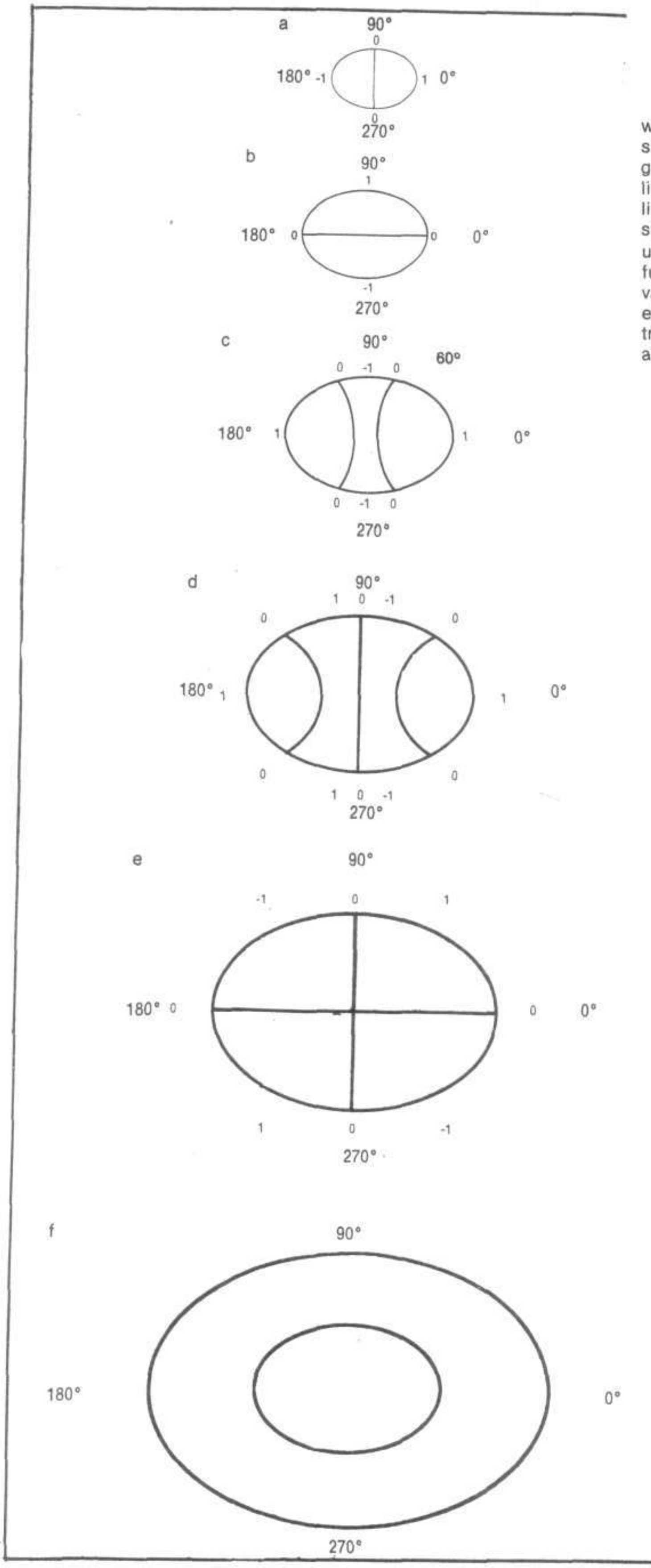
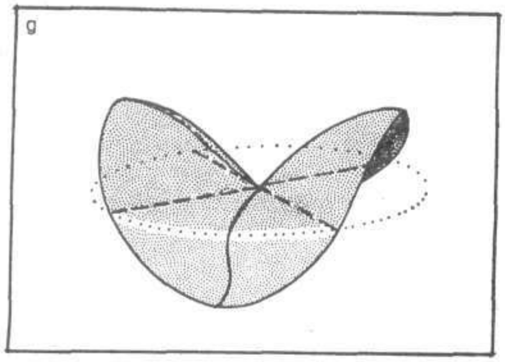
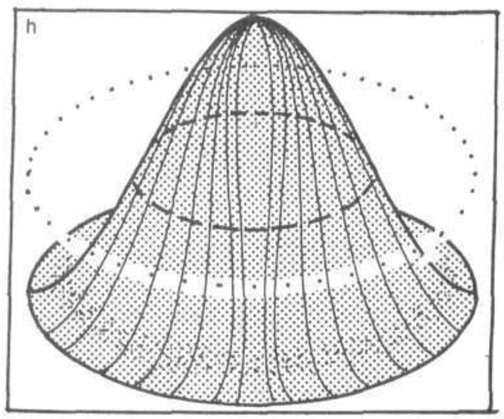


Figure 2
Mathematical Model Showing
Ellipse-Shaped Oscillation System

The elliptical shape approximates the actual shape of the wing-forming disc. The model is constructed so that as the size increases, the way it oscillates changes, just as the growth of the disc changes the pattern of its demarcation lines. Each pattern of oscillation is indicated by a set of lines which correspond to the nodal points of a vibrating string, and represent the stationary lines around which the up-and-down oscillations are occurring symmetrically. To further visualize the model, figures 2g and 2h represent the varying chemical concentrations across the surface of the ellipse; the height of the surface indicates the concentration of the chemical. Figure 2g corresponds to Figure 2e, and Figure 2h corresponds to 2f.





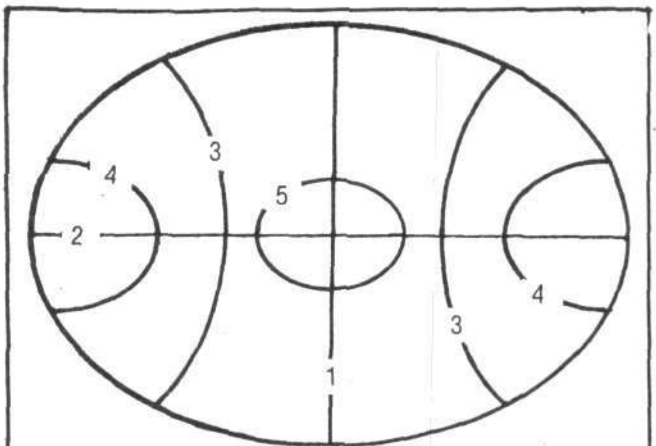
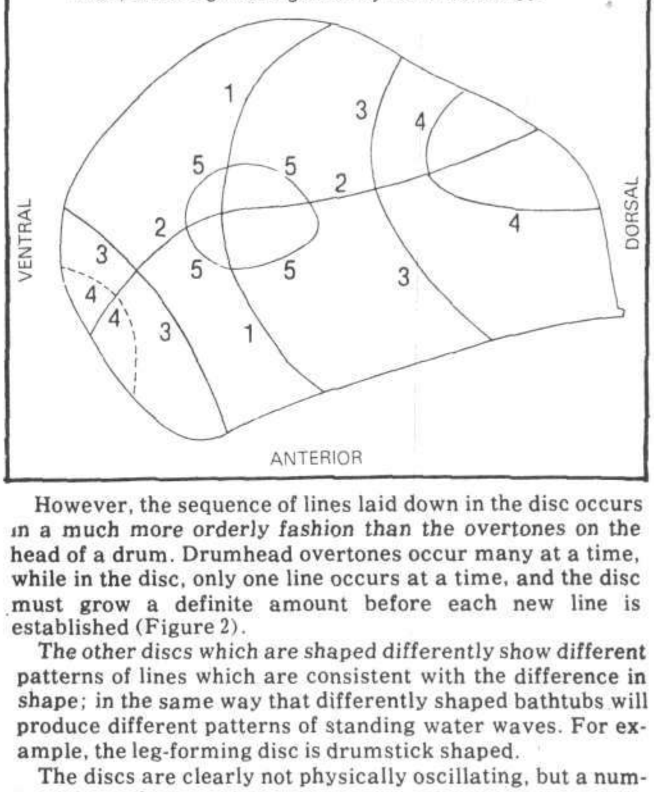


FIGURE 3
Mathematical Model Compared to
Actual Disc Patterns of Demarkation Lines

Above: The various oscillation modes from Figure 2 have been superimposed under the assumption that the disc has a physiological "memory" capacity.
Below: The actual imaginal disc with its demarkation lines. The similarity to the mathematical model is remarkable. Note that the difference in shape compared to a perfect ellipse has resulted in a shifting of the oscillation-pattern lines, but the general geometry remains intact.



However, the sequence of lines laid down in the disc occurs in a much more orderly fashion than the overtones on the head of a drum. Drumhead overtones occur many at a time, while in the disc, only one line occurs at a time, and the disc must grow a definite amount before each new line is established (Figure 2).

The other discs which are shaped differently show different patterns of lines which are consistent with the difference in shape; in the same way that differently shaped bathtubs will produce different patterns of standing water waves. For example, the leg-forming disc is drumstick shaped.

The discs are clearly not physically oscillating, but a number of simple physiologies can be postulated to support this kind of pattern. An included importance of these models is that they give direction to future research — they are in principle testable. For example, assume that the surface of the disc is secreting two chemical substances or "morphogens," C_1 and C_2, over the surface of the disc; and that the rate of this secretion is not uniform but depends on how much of each of the two substances is locally present at each point. Assume further that the presence of C_1 stimulates the production of C_1 but that the presence of C_2 inhibits the production of C_1. Assume further that the substances, once produced, can diffuse over the surface of the disc at a certain rate. If this process is allowed to continue for a time it is readily seen that oscillations in the concentrations of the substances will occur, for if C_1 stimulates the production of C_2 at some particular point on the disc, then the amount of C_2 will increase; but this will then cause the production of C_1 to decrease, leading to a decrease in C_2, etc. Notice that the initial setting into motion of this see-saw is a local increase in C_1, which could occur as a natural fluctuation of the system. The lateral diffusion of substances from areas of high concentration spreads this see-saw activity, leading to overall patterns of oscillations whose characteristic wave forms are determined by the size and specific shape of the disc. Again the analogy of a drum head is a useful, familiar image.

These considerations can be given mathematical expression, from which a precise geometry of the resulting wave forms can be deduced. The equation for the rate of change of the concentration of C_1 at any point is as follows:

$$\frac{\partial C_1}{\partial t} = F(C_1, C_2) + \nabla^2 C_1$$

where

$$\frac{\partial C_1}{\partial t}$$

means the rate that C_1 varies in relation to time, $F(C_1, C_2)$ is the rate of production of C_1 (which here depends on the local concentration of both C_1 and C_2), and the strange-looking $\nabla^2 C_1$ is a measure of how much the concentration is varying locally so we can get an idea of which way and how fast it will diffuse next. (Since diffusion generally goes from a high concentration to low concentration, the rate depends on how different the two concentrations are, that is, how steep is the slope of concentrations.)

A corresponding equation for C_2 can also be written to complete the description of the model. We now wish to solve these rate equations to obtain the actual amounts of the substances present at any time and at any point on the surface. For the purpose of a first approximation we will assume that $F(C_1, C_2)$ bears a direct relationship to C_1 and C_2, so that

$$F(C_1, C_2) = K_{11} C_1 + K_{12} C_2$$

where K , K are constant values.
We then get the rate equations:

$$\frac{\partial C_1}{\partial t} = K_{11} C_1 + K_{12} C_2 + \nabla^2 C_1$$

$$\frac{\partial C_2}{\partial t} = K_{21} C_1 + K_{22} C_2 + \nabla^2 C_2$$

Solving these equations for C_1 and C_2 gives a set of wave-patterns or modes of oscillations for the two substances, but the solution depends on the boundary conditions, that is, the shape as an ellipse, then the first few modes of oscillation would appear as in Figure 2.*

This pattern agrees fairly well with the data, but notice that the flattening of the end of the disc has slightly shifted all the lines, as a slight change in the shape of a violin would change its entire set of characteristic overtones. This brings us to a critical point which goes beyond Dr. Trabert's work explaining how a wing develops and brings us to the question of evolution itself.

The Problem of Evolutionary Change

Biological evolution is characterized by two apparently irreconcilable features. First, evolution procedes in "jumps," as attested to by the irregular fossil record. Second, biological systems are very complex, as any study of intermediary metabolism, cellular morphology, or ecological interrelationships demonstrates. How can such a complexity "jump" and still land on its "feet" to continue in a directed and coordinated fashion in a new mode of existence?

Previous attempts to determine a coordinated geometry for embryology have failed for several reasons. The notion of a gradient substance, secreted by one part of the embryo and diffusing to other parts, causing differentiation by creating a field, goes back to the nineteenth century. However, the gradient has always been assumed to vary smoothly, and not oscillate, so that the number of kinds, and points of origin of the gradients would have to be as complex or differentiated as the final differentiated embryo. Alternatively, the individual cells would have to make up for any lack of differentiation of the gradient by having individually different reactions to the same gradient, presumably based on differences in "gene expression" in the different cells.

The psychotic extreme of this position would maintain that every cell in the embryo is programmed as biochemically distinct and the embryo differentiates by each cell having unique instructions for cell-to-cell adhesiveness, cell migration, etc. Like the simple gradient hypothesis, it cannot explain how evolution could possibly jump. Clearly, jumps could not occur on the basis of Darwinian "random mutations" in the genetic material. More to the point, evolution is not a result of random mutations. Evolutionary development, on the contrary, is a *coordinated* series of shifts that the overall functioning of the organism in a way coherent with the biospheric expansion.

Assuming that the shape of the fruit fly discs in some way depend on genetic content, then the discs may represent just such a *coherent* system of amplification of genetic changes. As the diagrams 1-3 show, a small change in the boundary shape of the disc produces a coordinated shift of the disc's demarcation lines as a result of the intrinsic geometry of the entire structure. These changes very likely result in changes in the structure of the adult wing (though the precise mapping of the changes has not yet been worked out).

More fundamentally, the geometry of the entire development of an embryo, through its succession of stages, must be arranged in such a way that the successive stages are interlocked or interconnected, one with the next, so that a change in development in an early stage is tolerated through all the successive stages — they can coherently incorporate the change. The totality thus remolded moves toward increasing evolvability as a genereal capacity as a result of such reorderings.

The organism resulting from this coherent series of changes must then become a part of the biosphere which not only functions at a more developed level, but, more important, has the capability to undergo such changes at an accelerating rate. This is the process that characterizes evolution (see Lerner's article in this Newsletter).

While this may appear to put too many constraints on the biological material, in fact, these are the *minimum* requirements for advanced species evolution to occur at all. Ultimately the critical value of the specific (intrinsic) geometry that characterizes any mode of enforcing such an overall coherence is the property of that geometry that ensures "appropriateness" for biospheric evolution.

As a measure of the power of the *Drosophila* disc as such a coordinated amplification system, another set of observations has shown that one entire adult structure can change into another as an apparent result of only a single genetic change. All the various disc-formed structures in the adult fly are actually interconvertible, in that with a certain frequency, a fly will develop that has a wing where its leg should be, or a leg growing out of its head instead of an antenna. The frequencies of these interconversions are not all the same, but vary overall in a way which is consistent with a three-variable system, each of which has two states, with each structure having one or the other value for each of

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*The approach used here for solving these equations is as follows. Using a more convenient notation, the equations are:

$$\frac{\partial x}{\partial t} = F(x, y) + D_1 \nabla^2 x$$

$$\frac{\partial y}{\partial t} = G(x, y) + D_2 \nabla^2 y$$

where D_1 and D_2 are the diffusion constants. In general $D_1 \neq D_2$.

These equations are linearized about the spatially homogeneous steady state by substituting

$$X(\vec{r}, t) = X_0 + x(\vec{r}, t), \quad Y(\vec{r}, t) = Y_0 + y(\vec{r}, t),$$

where $F(X_0, Y_0) = 0$ and $G(X_0, Y_0) = 0$,

and retaining only terms up to first order in x and y in a Taylor expansion of F(X,Y) and G(X,Y). The resulting linear equations in x and y are solved by separating out the time-dependence through the substitutions

$$x(r, t) = x'(r)\, e^{\lambda t}, \quad y(r, t) = y'(r)\, e^{\lambda t},$$

and diagonalizing the remaining spatially dependent coupled equations. The two separated equations are Helmholtz-type equations whose solutions in two dimensions are, for example, Bessel functions if the spatial coordinates chosen are polar coordinates, or are Mathieu functions if elliptical coordinates are chosen.

The complete solution on a circle can be written:

$$\begin{bmatrix} x(r, \phi, t) \\ y(r, \phi, t) \end{bmatrix} = \sum_{i=+,-} \sum_{j=1}^{\infty} \sum_{m=0}^{\infty} \begin{bmatrix} a_{mji} \\ b_{mji} \end{bmatrix} e^{\lambda_{mi} t} J_m(k_{mj} r) \cos m\phi.$$

On an ellipse, the solutions are:

$$\begin{bmatrix} x(\xi, \eta, t) \\ y(\xi, \eta, t) \end{bmatrix} = \sum_{i=+,-} \sum_{j=1}^{\infty} \sum_{m=0}^{\infty} \begin{bmatrix} a_{mji} \\ b_{mji} \end{bmatrix} e^{\lambda_{mi} t} \quad [Ce_m(\xi, s_{mj}) ce_m(\eta, s_{mj}) +$$

$$S_{mji} Se_m(\xi, s_{mj}) se_m(\eta, s_{mj})]$$

where ce_m and se_m are periodic cosine- and sine-elliptic Mathieu functions, respectively, of integral order and Ce_m and Se_m are the corresponding non-periodic (or modified) Mathieu functions. ξ and η are the elliptical coordinates tracing out confocal ellipses and hyperbolae, respectively, and $s_{mj} = h^2 k_{mj}^2$ where h is one-half the

the three variables. Thus, if two different structures, say the wing and the antenna, differ by only one of the postulated variables, and the antenna and leg differ by another one of the variables, then the interconvertibility rate of wings and antennae will equal the rate for antennae and legs, but the rate for wings to legs will be much lower, since it requires a change of two of the variables. A self consistent system using the interconversion rates of all the disc-formed structures has been worked out along these lines and agrees very well with the data. Thus, there is strong mathematical evidence that a single gene change can change one organ into another.

When an experimental embryo that will develop into a fly with a leg in place of an antenna is examined, the imaginal disc responsible for the leg is found to have the shape of a leg disc, not an antenna disc.

Although we are not implying that it is merely the shape of the disc that determines which structure will be produced, this does imply that the shape determines more than merely the proportions of the final structure. This has obvious implications for evolution, but must await more work on the actual comparative geometry of the embryology of the various structures.

On a broader level, the work has implications for metabolic evolution as well as structural evolution. Dr. I. Prigogine has formulated the mathematics of mutually catalytic or inhibitory chemical reactions, very similar in form to the above model for morphogens on the disc surface. In experiments combining such chemical systems in a test tube Prigogine has found that not only does the system oscillate in terms of the chemical composition, but it also forms bands or other stratifications, that is, it oscillates in space as well as in time. This chemical phenomenon corresponds to the chemical oscillations presumed central to the structural phenomenon we associated with the geometry of the *Drosophilia* wing-disc.

Metabolism is a coordinated system of thousands of enzymatically catalyzed chemical reactions which, among other things, convert food into energy and build up food derivatives into the substances which make up an organism. These reactions occur in sequences that are overwhelmingly characterized by interconnections and cross-stimulation or inhibition of one sequence by another. While biochemists are aware of these interconnections as they function to coherently shift the entire array of reactions — for example in response to something as simple as a change in diet — what is usually missed is the possible importance of this interconnectedness for evolution. The argument runs entirely parallel to the possibility for coherent change in the *Drosophila* wing structure as a result of marginal changes in the disc.

Again, the question of genetics must be addressed. The one-gene-one-enzyme hypothesis — that one gene produces one enzyme — is as valid as the observation that one disc produces one wing. So what? A positive conception of genetics must proceed from an understanding of the lawfulness of the development of a biological topology or interconnectedness *which can evolve*. Genetic material serves only to mediate that evolution. The gene which plays this marginal but critical role in producing the new structure, also functions as the "conservative" element in evolution, conserving the old in the new. The disc mode of evolution is now no more than a tertiary part of biological evolution, and biological evolution itself is only a tertiary part of the current dominant mode, social evolution. The disc physiology has been subsumed under the more advanced modes, and therefore still exists today.

Since the particulars are different for each qualitative evolutionary "jump," no single evolutionary stage can supply an adequate notion of the functioning of genes. What is required is a concept of gene activity which begins historically, tracing the qualitatively new capacities of genes through successive levels of ecology to develop a positive conception of genetics in a transfinite sense.

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interfocal distance of the ellipse. For both the circle and the ellipse, k_{mj} is the wave number of that mode consisting of m^{th} Bessel or Mathieu functions such that the j^{th} zero in the derivative of its "radial" part matches the boundary condition

$$dJ_m(k_{mj}r)/dr = 0 \text{ or } dCe_m(\xi, s_{mj})/d\xi = 0$$

at the edge $r = r_0$ or $\xi = \xi_0$, respectively. a_{mji}, b_{mji}, and S_{mji} are constants determined by initial and boundary conditions. In the text we use the shorthand notation Ce_m for the mode

$$Ce_m(\xi, s_{m1})\, ce_m(\eta, s_{m1})$$

and Se_m for the mode

$$Se_m(\xi, s_{m1})\, se_m(\eta, s_{m1}).$$

The temporal eigenvalues, λ_{mi}, depend on the diffusion constants D_1 and D_2, on the reaction kinetics linking X and Y (autocatalytic coefficients K_{11}, K_{22} and cross-catalytic coefficients K_{12}, K_{21}) and on the wave number k_{mj} (which is inversely proportional to the chemical wavelength of the m^{th} mode) through the relation:

$$\lambda_{m\pm} = \tfrac{1}{2}[K_{11} + K_{22} - k_{mj}^2(D_1 + D_2 \pm \{[K_{11} - K_{22} - k_{mj}^2(D_1 - D_2)]^2 + 4K_{12}K_{21}\}^{1/2}].$$

Under the appropriate conditions, given by

1. $K_{11} + K_{22} < 0$
2. $K_{11}K_{22} - K_{12}K_{21} > 0$
3. $(K_{11} - K_{22})^2 > -4K_{12}K_{21}$
4. $D_1K_{22} + D_2K_{11} > 0$
5. $\left[\left(\frac{D_1}{D_2}\right)^{1/2} K_{22} - \left(\frac{D_2}{D_1}\right)^{1/2} K_{11}\right]^2 > -4K_{12}K_{21}$

the real part of λ_{m+} is positive only in the neighborhood of a particular value of k_{mj}, say k, corresponding to the natural chemical wavelength of the system. Therefore, only that mode (m,j) will grow which satisfies the radial boundary condition with $k_{mj} = k$.

Electron Beam Research Breakthrough at Sandia Lab

Testimony by officials of the federal Energy Research and Development Administration indicates that U.S. electron-beam pellet fusion researchers at Sandia Weapons Lab in New Mexico have duplicated what Soviet researchers led by L.I. Rudakov accomplished one year ago: They have experimentally produced controlled thermonuclear fusion reactions, utilizing the electron-beam pellet approach.

Although details are still being withheld under top-secret classification wraps, preliminary analysis points to the fact that the Sandia researchers utilized the same method Rudakov revealed to U.S. scientists last year. With this new experimental breakthrough, U.S. electron-beam pellet fusion scientists can demonstrate the feasibility of this approach to harnessing the vast energies of nuclear fusion reactions by 1980 with the completion of the construction of their next planned experimental facility.

In testimony March 2 before the House Science and Technology subcommittee on energy, Dr. C. Martin Stickley, the director of the ERDA Laser Fusion Division, reported that researchers at the Sandia Laboratories "produce measurable numbers of thermonuclear neutrons...on Proto I." Furthermore, he went on, "the most important achievement has been the experimental and theoretical observation of enhanced electron beam energy deposition in thin shells over what had been predicted from simple models. This order-of-magnitude enhancement reduces the requirements on the design of targets and generators for electron beam fusion. New target designs are yielding evidence of thermonuclear neutron production."

During Dr. Rudakov's visit to Sandia Labs in July 1976 — when he described the details of his successful experiments utilizing soft X-rays from e-beams — he announced that the USSR was building an electron beam experiment, the Angora V, which would constitute the core of an electron-beam fusion power reactor. With the latest Sandia experimental breakthroughs, it now appears that the U.S. Electron Beam Fusion Facility at Sandia will be capable of producing net fusion energy.

The Proto II electron beam facility just last week began operation and develops beams with powers up to eight trillion watts of one and a half million volt electrons in pulses lasting 24 billionths of a second and total energies of 100,000 joules. The Electron Beam Fusion Facility will be similar except that its power will be five times greater and the total energy output also five times Proto II.

Researchers at Sandia have also developed a new method of getting around the chief technological roadblock to realizing economic and reliable power reactors based on e-beam pellet fusion. Under normal conditions the diode which generates the electron beam must be within a few feet of the pellet. This would lead to its rapid deterioration in a power reactor in which up to 10 microexplosions per second must be obtained if significant power output is to be reached.

Sandia researchers recently demonstrated that if the electron beam is enclosed in a separately produced plasma, the electron beam can be transported over several meters (up to 10) and be kept stable and focused.

These developments, together with utilization of disposable plasma anodes in the electron beam diode, brings the technology needed for power reactors within the existing state of the art. A similar situation does not presently exist for laser fusion since the only existing high-power laser systems are very inefficient. High-power laser systems convert less than 1 percent of their input energy into the actual laser beam output, while electron beams convert up to 50 percent of the input energy into the output beam. Therefore much lower pellet gains can produce net energy output with e-beam systems.

Just as in the case of laser-pellet and hydrogen bomb fusion, electron beam pellet fusion uses inertial confinement to obtain net fusion energy generation. In all three cases an ignitor (a laser or electron beam, or for an H-bomb, a nuclear fission bomb) is used to compress and then heat fusion fuel to temperatures at which thermonuclear reactions are ignited. The basic idea of inertial confinement as opposed to magnetic confinement is that the fusion fuel is compressed to densities sufficient that the fuel undergoes significant amounts of fusion before it blows apart; that is, it is only confined by its own inertia. In laser and electron beam pellet fusion only very small quantities of fusion fuel can be ignited in this way.

MIT's Alcator Nears 'Breakeven' in Fusion

The small, high-density Tokamak at the Massachusetts Institute of Technology, the Alcator, has come close to achieving "scientific breakeven" in fusion energy production, scientists at the laboratory announced in March. The new and striking success reported by the scientists at one of the small U.S. government-funded experiments is an embarrassing rebuff to the Carter administration contention that fusion research is lagging — the justification for a 20 percent cutback in the fusion program.

Researchers at the MIT laboratory have designed and perfected a small, high magnetic field Tokamak (a doughnut shaped plasma container). The device has generated plasmas that have come within a factor of three of the required density-time product conventionally used to measure progress toward energy breakeven conditions, and has done this in terms of the best-understood plasma behavior found in any device. The results from the Alcator machine are most important because they were the predicted results of a long series of experiments for which an adequate theoretical understanding exists.

The U.S. assistant administrator for advanced energy systems described the Alcator results as follows: "The significance of this world record event is its demonstration that researchers can control a plasma very close to the conditions required for fusion energy breakeven, getting as much energy from plasma fusion as was required to originally create the plasma."

The Fusion Energy Foundation estimates that a $30 million investment could build a throwaway machine that would reach breakeven within a matter of two years, merely by scaling up presently well-understood plasma behavior in the Alcator.

Los Alamos Lab Achieves Fusion Using Carbon Dioxide Laser

Researchers at the U.S. Los Alamos Scientific Laboratory reported in mid-March that they had obtained laser pellet fusion utilizing a carbon dioxide gas laser. The scientists stated that these experimental results indicate that as much as "10 to 20 years could be lopped off" previous projections for the time it would take to develop commercial laser fusion power plants. It is now expected that a prototype fusion generator could be operating by the early 1980s. This significant breakthrough in harnessing the virtually infinite energy of nuclear fusion reactions is based both on major technological and frontier scientific advances. Like the hydrogen bomb, laser pellet fusion is based on inertial confinement. Laser beams can compress and heat only very small quantities of fusion fuel and therefore produce only microexplosions like those in a gasoline engine.

Until now the only high-energy laser system capable of producing the conditions for inertial confinement fusion have been solid glass lasers. But these glass lasers to not appear to meet the minimal technological needs of actual power plants. They are very inefficient; they must be cooled down after each "shot"; and they cannot be straightforwardly scaled up to the sizes needed for power plants.

Carbon dioxide gas lasers, on the other hand, have efficiencies of up to 5 percent and very high repetition rates. According to scientists at Los Alamos, scaling carbon dioxide lasers up to the sizes and shot rates needed for power plants is within existing "state of the art" technology. The main problem has been that carbon dioxide laser light has a wavelength (10 microns) 10 time sthat of glass lasers (1 micron). From the initial linear physics analysis it appeared that the long wavelength carbon dioxide could not be efficiently coupled into the pellet. But, more recent theoretical and experimental work had pointed to the fact that nonlinear laser-plasma interaction led to efficient coupling of the laser beam into the pellet regardless of the wavelength.

In experiments beginning in October 1976, scientists at Los Alamos demonstrated that these new nonlinear theories were indeed correct. A two-beam, carbon dioxide laser system with a total energy of 200 joules delivered to the pellet in less than a billionth of a second produced up to 100,000 thermonuclear neutrons. This is 10,000 times fewer than the billion neutrons produced with glass laser systems at Lawrence Livermore Lab late last year, but these Los Alamos experiments do demonstrate efficient coupling of carbon dioxide lasers.

An eight-beam carbon dioxide laser system will begin operation at Los Alamos in 1978. With the recent Carter administration cuts in the fusion research budget, the High Energy Laser System at Los Alamos — an upgrade of the eight-beam system which will reach breakeven — has been set back several years beyond its originally scheduled start-up date of 1981, if it is authorized at all. An expansion of the existing program demonstration could bring on-line commercial prototype laser fusion power reactors by the early 1980s.

Biology Research Notes

DNA Recombination Research Under Attack

DNA recombination research came under attack at a March forum of the National Academy of Science for more than 200 nationally known biologists. The Friends of the Earth and various other so-called ecology groups repeatedly assailed this promising technology on the basis of the remote possibility that scientists might create a "monster" in their laboratories.

In reality, highly regulated research on DNA recombination has been conducted safely without serious problems for more than four years. The research is now verging on making a fundamental breakthrough in the nature of genetic interactions that would have revolutionary implications for increasing agricultural output and the human lifespan. For example, genetic splicing of nitrogen-fixing bacteria will greatly increase crop yield, using less fertilizer. In the same way, the technique could be used for medical treatment of genetic-deficiency diseases such as diabetes. In this case insulin-synthesizing bacteria could be developed that would live symbiotically in insulin-deficient diabetics.

What's Behind the Saccharin Ban?

The Food and Drug Administration banned the use of saccharin in March charging that the artificial sweetener was banned primarily on the basis of a Canadian experiment that showed an increase of cancer in rats which were fed saccharin in equivalents of a human being ingesting 800 cans of diet soda per day all his life.

The most dangerous aspect of the FDA decision is the erroneous idea that cancer is caused by environmental factors. To be sure, there are factors in the environment that increase susceptibility to cancer. But this does not mean that cancer can be treated by removing all these factors. Proven cancer-causing agents must be minimized, but cancer cannot be cured by eliminating the chemicals that in dosages *millions* of times greater than occur naturally are associated with cancer in laboratory animals.

There is a growing danger that instead of advancing the fight against cancer on basic scientific research fronts, such efforts will instead go to remove all suspected carcinogens from the environment.

The supporters of the FDA ban have proposed that the FDA become an independent and "nonpolitical" group to assess the effects of any chemical and ban those it considers unsafe. The impact of such an institution would be similar to that of the Environmental Protection Agency which has not protected the environment but has severely disrupted industry and employment.

The Ford Foundation Nuclear Energy Report: Carter's No-Energy Program

The Ford Foundation issued a stud of nuclear power March 21 that wa acknowledged by its authors to be a preview of the energy program President Carter is expected to announce to Congress April 20. The study, Nuclear Power: Issues and Choices, *demands that the more advanced nuclear technologies, fast breeder fission reactors, plutonium reprocessing, and fusion power either be junked or deferred until the middle of the next century, leaving the U.S. to subsist on "energy conservation" and "increased reliance on coal."*

Less than three weeks after the issue of the report, President Carter indefinitely banned the commercial reprocessing and recycling of plutonium, embargoed exports of equipment and technology that could be used for uranium reprocessing, and banned the fast breeder reactor and the development of alternate breeder programs.

The following are excerpts from an analysis of the Ford report that first appeared in New Solidarity, March 29, 1977. The full analysis is available from the FEF.

If adopted as national policy, the Ford Foundation prescriptions would throttle nuclear power development and crush the U.S. economy under astronomically high costs for inefficiently produced energy....

The study eschews the raving antitechnology slogans of the Ford Foundation's "radical ecologist" operations, to present itself as an "open-minded" argument for "a reasonable amount" of growth and nuclear power development. But some nuclear technologies are not worth the effort to develop them,the report claims,and others are little more than "make your own nuclear bomb" kits for foreign and domestic terrorists. (It is no accident that the MITRE Corporation overseers of the Ford project are also the leading proponent of this viciously untrue "nuclear terrorism" blackmail.)

The "growth" this report promises is thus only bait (and at 2 to 3 percent a year, pretty skimpy bain at that). The hook is the fact that the incompetent investment and development policies advocated by the report are designed to push energy costs through the ceiling, making even the most harebrained coal gasification and solar power porkbarrels "economically competitive" with conventional energy modes....

Beneath its luxuriant array of cost analyses and computer run-throughs, the message of *Nuclear Power: Issues and Choices* is straightforward. It agrees that nuclear power is as safe as or safer than coal, on the whole economically competitive, and environmentally acceptable, even taking into consideration the problems of nuclear waste disposal.

But while conventional nuclear reactors are given the okay, the report insists that the "international and social costs" of plutonium reprocessing and recycle — specifically, the danger of "nuclear terrorism" — dictate that development of this technology be "deferred indefinitely." Also, the fast breeder nuclear fission reactor is to be greatly deemphasized, and its development "can safely be postponed beyond the end of the century."

To prevent the spread of nuclear wea pons, the study calls for tight restrictions on the export of nuclear power technologies to other countries, particularly to the underdeveloped sector. "We believe the consequences of the proliferation of nuclear weapons are so serious compared to the limited economic benefits of nuclear energy that we would be prepared to recommend stopping nuclear power in the United states if we thought this would prevent further proliferation," the study declares. It demands that the U.S. make "efforts to achieve similar (refusal to export nuclear technology) by other suppliers," that is, Western Europe.

While conservation, enforced by higher energy prices, and increased use of coal (both in standard ways and for coal gasification) are supposed to take care of the bulk of the country's energy requirements for decades to come, the report also discusses possible energy alternatives for the future. Fusion power, the study admits, "offers the promise of practically unlimited energy," but, it lies wildly, so does solar power. Neither will be commercially feasible until well into the 21st century, however. . . .

The "fusion-fission hybrid," a reactor that uses a fusion process to initiate fission and represents an important halfway step to fully operative fusion reactors, is not worth the effort, the report adds. "It would have...most of the other negative characteristics of the breeder in terms of safety and plutonium traffic," it says, and worse, "would involve all of the technical complexity of fusion reactors . . ."

The nominally pro-nuclear stance of the *Nuclear Policy* crew boils down to out-and-out-sabotage in even more immediate terms. Today's light water fission reactors use naturally occurring uranium as the basis for their fuel, and because of the relative scarcity of uranium, it represents only a tiny fraction of the world's energy resources.

The Ford Foundation proposal is to effectively outlaw plutonium and all the technologies more advanced than the light water reactor, which will be left to the mercies of the National Environmental Protection Act, the courts, and the "Save the Snail Darter" gangs.

In addition, killing the technological development of the fast breeder will both directly and indirectly undermine any technological development of fusion power. Likewise, by junking the fission-fusion hybrid, which depends on breeder technology, the *Nuclear Power* scheme will sever one of the most important links to fusion. With the hybrid option available, existing scientific achievements in fusion research are already sufficient for constructing an economical hybrid system; this is precisely what the Soviet Union is currently planning the construction of the Tokamak T-20 by 1985. Even if the optimum 1980s timetable for fusion development is not reached, these hybrid reactors could assure us plenty of cheap energy in the interim. But to the *Nuclear Power* experts, "there appears to be little reason to pursue this approach."

FEF NEWS HIGHLIGHTS

Stockholm Conference Draws 90 Scientists, Gov't Officials, Diplomats, and Journalists

The Fusion Energy Foundation conference in Stockholm March 30 drew more than 90 scientists, government officials, diplomats, and journalists and resulted in a de facto European-wide coordinating committee to oppose the zero-growth environmentalist movement against nuclear energy. The daylong conference, held at Stockholm's Royal Technological University, was entitled "The Future of Fusion Energy: A Challenge to Industry."

The main conference speakers were Dr. Steven Bardwell, plasma physicist on the FEF U.S. staff; Dr. Hans Persson, an associate of the Euratom fusion research group in Brussels; and Professor Bo Lehnert, plasma physicist at the Royal Technological University in Stockholm and the head of Sweden's fusion research effort.

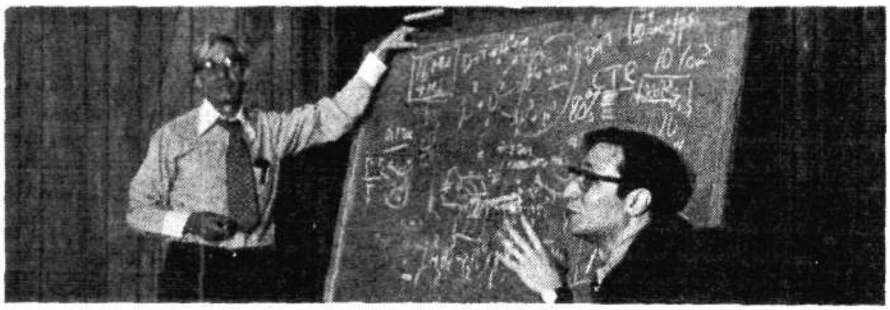
In his keynote speech, Bardwell described both sides of the international energy battle — the zero-growth conservationists and those fighting for progress and fusion energy. After Bardwell outlined the FEF and U.S. Labor Party's organizing for fusion power and the increasing sentiment in Congress to restore the cuts in President Carter's federal budget for fusion and fission energy development, a top official of a Swedish nuclear reactor contractor turned to the spokesman of the government's Ministry of Industry and demanded that the ministry "launch an organizing operation for nuclear energy" along the FEF model. The ministry official answered with a call for a national propaganda and organizing thrust against Sweden's zero-growth-ecology movement, which has played a central role in sabotaging Sweden's nuclear development.

Persson described the European fusion effort and linked the FEF organizing efforts in the United States to the fight against the cuts in the Joint European Torus, JET, which has yet to get siting agreement from European Economic Community members. Persson concluded with a challenge to the industrialists present: "The point at which fusion energy ceases to be merely a question of scientific laboratory research and becomes a question of productive investment depends solely on the willful decision by industry itself."

At the request of the audience, Lehnert made an unscheduled address, outlining the current state of fusion research and the prospects for the immediate future. Moved by the implications of the organizing conference for the realization of his decades-long research, Lehnert concluded: "This is the happiest day in my life."

Among the participants at the spirited conference were: 23 nuclear energy and aerospace firms from Sweden and Denmark, including Volvo, ASEA, Stal-Laval, Snadviken, Granges, and AGA; and representatives of several foreign embassies including Brazil, Czechoslovakia, Great Britain, the German Democratic Republic, Hungary, Libya, India, Iran, Pakistan, and the Soviet Union.

The FEF conference and Bardwell's European tour received excellent press coverage.



Dr. Winston Bostick (right), FEF Advisory Board member, and Dr. Morris Levitt, FEF director, answer questions at a Princeton, N.J. FEF forum.

In the first three months of 1977, FEF spokesmen addressed more than 100 special meetings, legislative hearings, university seminars, and industrial meetings on the topics of fusion power and a sane U.S. energy policy

FEF's Levitt Tours Texas

Dr. Morris Levitt, director of the Fusion Energy Foundation, opened a 12-day tour of Texas in early April with addresses before the five major universities in the Dallas-Fort Worth area and a blitz of media appearances. Levitt spoke at the University of Texas at Dallas, Texas Christian University, Southern Methodist University, North Texas State University at Denton, and the University of Texas at Austin.

Levitt told a Dallas press conference April 4: "I am here in Texas, a leading world center of advanced technology, defense, and aerospace production and agriculture, to call on Texans to join with efforts in the U.S. Congress and legislatures of other states and regions to put through a high-energy, advanced technology program for America.... The Texas senate and congressional delegation has a key strategic role to play in this effort. We don't have to wait for April 20 to determine what President Carter's energy policy will be. The pricing policies outlines by (presidential energy advisor) Schlesinger April 3, combined with Carter's proposed R and D cutbacks would mean that we would never get fusion, while the Soviet Union is now producing a fusion Sputnik."

Levitt's tour was covered widely by the press including a 30-minute ABC-TV interview aired April 7. During an interview on Dallas's most widely listened-to talk show, moderated by former Dallas mayor Wes Wise, Wise interrupted Levitt at one point to read the text of House Majority leader Jim Wright's call for a "Manhattan-style" development of fusion power as the solution to the energy crisis. Texas Congressman Wright had made the call in a Washington, D.C. speech in late March. Wise then told the audience that if they wanted a memorial for fusion development to be introduced in Texas, "people should call their state legislators."

At the time of this writing one Texas state senator is preparing to introduce a fusion memorial bill to the state legislature.

Memorial Urging Fusion Development Now Before 8 State Legislatures

The Maryland State Legislature passed legislation April 9 calling on Congress to "foster the development of the scientific and engineering know-how essential for bringing on-line controlled nuclear fusion reactors." The fusion memorial was passed unanimously by the state senate and by a vote of 108-3 in the state house of delegates.

The Maryland legislation was the first fusion bill to reach the floor in the eight state legislatures where fusion memorials have been introduced. Fusion memorials initiated by the U .S. Labor Party and backed by bipartisan coalitions are now before the legislatures of Connecticut, Illinois, Maryland, Michigan, Pennsylvania, Oregon, and Washington. It is expected that fusion energy memorials will be introduced in Ohio, New York, New Jersey Colorado, and Vermont during the month of April.

The Maryland Bill

In the Maryland state legislature, which is under heavy Carter influence, it was initially impossible to obtain a sponsor for the bill. Finally Rep. George Price (R-Baltimore County) introduced it at the request of the U.S. Labor Party.

The well-attended Fusion Energy Foundation Conference in Baltimore March 2 helped build a climate of support for the legislation. The conference, cosponsored by the Maryland engineering-architectural firm of Harrison Associates, was attended by representatives of the Energy Research and Development Administration, Baltimore Mayor Schaeffer's office, and numerous corporations and local business groups. It also received prominent coverage in the *Baltimore Sun* and the city's financial *Daily Record*.

Simultaneously, the Maryland legislation gathered support from local Chambers of Commerce and is being considered by all leading union locals in the Baltimore area.

Labor-Industry Coalitions

The use of memorial resolutions to Congress is modeled on the early 1800 American practice whereby state legislatures, workers associations, and professional societies passed memorials to give Congress direction on the urgent policy questions facing the young republic. Today's fusion memorials, similarly, have been backed by coalitions of labor and industrialist support. In Washington state, Oregon, Michigan, Wisconsin, and Pennsylvania, the fusion energy memorials have between 10 and 20 leading legislative sponsors from both the Democratic and Republican parties, coalitions for growth that now are replacing the domination of the conservationists.

In Michigan, where Governor Milliken announced plans to turn the state into "the solar capital of the nation," the memorial was introduced by 18 Republican and Democratic sponsors.

The Michigan sponsors included Assistant House Majority Leader Tom Anderson, the Chairman of the Energy, Technology, and Science Committee of the National Association of State Legislators, a group whose members have backed the Carter conservation zero-growth approach to energy.

In the Northwest

In Washington state, the Senate Energy Committee unanimously voted up a memorial calling on the Congress to "undertake the measures necessary to accelerate and broaden the research and development of controlled fusion reactions" and "enact complementary enabling measures to develop fossil fuels usage and nuclear energy expansion under existing technologies to bridge the period between now and the target period of the mid-1980s when controlled fusion energy can 'come on line.' "

This fusion resolution caused a complete realignment in the legislature and the political factions in the state. Old-line Democrats such as former Senate Majority leader August Mardesich and Senate Energy Committee Chairman Max Benitz supported the resolution, which was also sponsored by leading Republican Senators Kent Pullen and Bob Lewis.

The battle lines were drawn clearly when Fusion Energy Foundation Director Dr. Morris Levitt testified before the Senate Committee on Energy and Utilities Feb. 17. There, angry pro-Nader legislators demanded the deletion of the resolution's references to the historical U.S. commitment to progress and the resolution's disavowal of the philosophy of zero-growth. The legislation, SJM No. 120, is expected to reach the Senate floor in April. Washington state AFL-CIO leadership and the state's strong Building Trades lobby have also split over whether to support the bill.

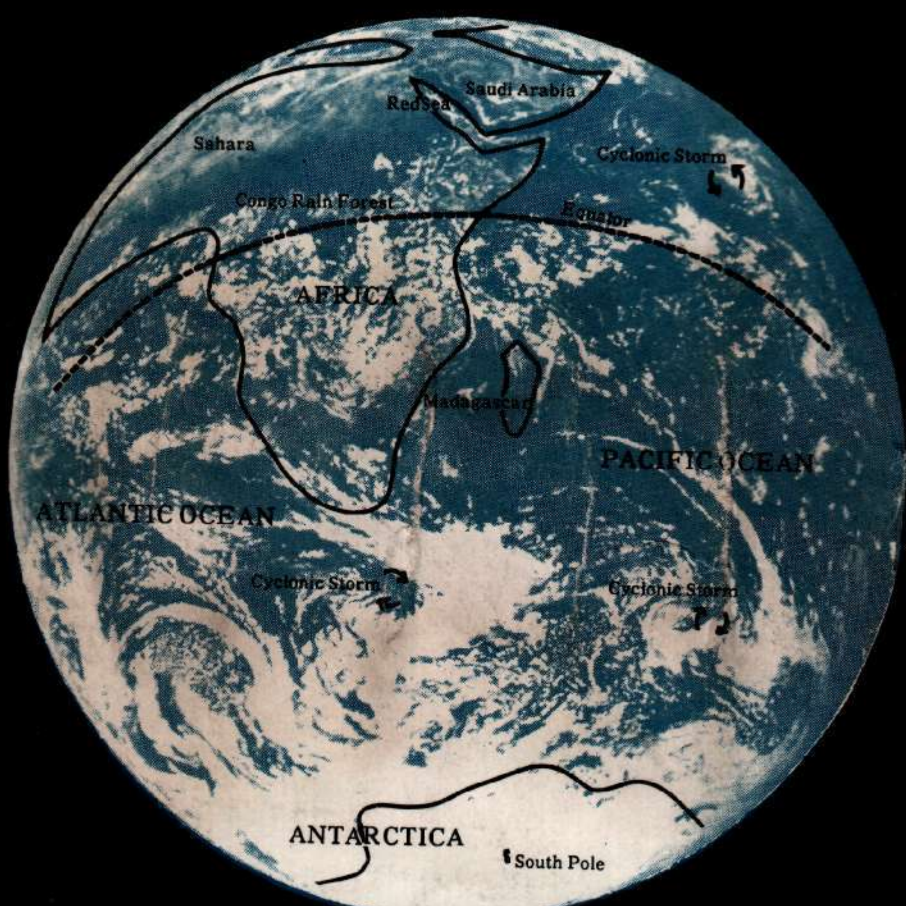
In Oregon, a bipartisan grouping including nine Democrats and six Republicans has introduced a fusion energy memorial in both chambers, HJM No. 5, which has been referred to the House Trade and Economic Development Committee. In February, the newspaper of the Oregon State AFL-CIO endorsed the legislation while simultaneously urging the defeat of five pieces of zero-growth energy legislation.

For up-to-date information on the fusion memorials, contact the FEF national office.

The Michigan Fusion Resolution

A town meeting in Livonia, Mich. April 3 unanimously passed the following resolution in support of the development of fusion power. The meeting, attended by more than 100 persons, was jointly sponsored by the U.S. Labor Party, the Daughters of the American Revolution, the American Legion, the Junior Chamber of Commerce, the Interested Democrats and the Republican Party.

We overwhelmingly endorse the legislation to expand fusion energy development introduced by State Senator Brotherton in the Michigan State Legislature. We further call for the formation of a Coalition for Energy Development to ensure that the Michigan Legislature and other public officials act to save the future of this state and nation based on expanding energy and industrial development. We will do everything possible to guarantee that Congress has the backbone to reject President Carter's energy research cuts. Our first task is to ensure the passage of HCR-143 (The Michigan fusion memorial — ed.).


Saudi Arabia
Red Sea
Sahara
Cyclonic Storm
Congo Rain Forest
Equator
AFRICA
Madagascar
PACIFIC OCEAN
ATLANTIC OCEAN
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Cyclonic Storm
ANTARCTICA
South Pole