The Bhaktivedanta Institute
Monograph Series Number 1

WHAT IS MATTER

AND

WHAT IS LIFE?

by
Thoudam D. Singh, Ph.D.
(Svarūpa Dāmodara Dāsa Brahmacārī)
Richard L. Thompson, Ph.D.
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The Bhaktivedanta Institute Monograph Series:

Number 1. What is Matter and What is Life?
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*This monograph forms part of a forthcoming book, *The Origin of Life and Matter*, by Thoudam D. Singh, Michael Marchetti, and Richard L. Thompson.

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The Bhaktivedanta Institute

Founder — Ācārya

His Divine Grace A. C. Bhaktivedanta Swami Prabhupāda

Dedicated to His Divine Grace

A. C. Bhaktivedanta Swami Prabhupāda

Who so kindly taught us that the goal of all scientific knowledge is to understand:

kṛṣṇas tu bhagavān svayam

(*Śrīmad Bhāgavatam* 1.3.28)

About Bhaktivedanta Institute

Bhaktivedanta Institute is a center for advanced study and research into the Vedic scientific knowledge concerning the nature of consciousness and the self. The Institute is the academic division of the International Society for Krishna Consciousness. It consists of a body of scientists and scholars who have recognized the unique value of the teachings of Krishna Consciousness brought to the West by His Divine Grace A. C. Bhaktivedanta Swami Prabhupāda. The main purpose of the Institute is to explore the implications of the Vedic knowledge as it bears on all features of human culture, and to present its findings in courses, lectures, monographs, books, and a quarterly journal, *Sa-vijñānam*.

The Institute presents modern science and other fields of knowledge in the light of Vaiṣṇava philosophy and tradition, providing a new perspective on reality quite different from that of our modern educational systems. One reason for the increasing interest of modern intellectuals in Śrīla Prabhupāda's teachings is doubtlessly the growing awareness that in spite of great scientific and technological advancements, the real goal of human life has somehow been missed. The philosophy of Bhaktivedanta Institute provides a meaningful answer to this concern by proposing that life—not matter—is the basis of the world we perceive.

The central doctrine of modern science is that all phenomena, including those of life and consciousness, can be fully explained and understood by recourse to matter alone. The dictum that "life is a manifestation of matter" is, indeed, the ultimate rationale for the entire civilization of material aggrandizement. The Vedas, on the other hand, teach that conscious life is original, fundamental, and eternal. This is the essence of *Bhagavad-gītā*—"*ahaṁ sarvasya prabhavo mattaḥ sarvaṁ pravartate.*" (10.8) On this fundamental and critical point, modern science and Vedic knowledge find themselves opposed.

Bhaktivedanta Institute is dedicated to disseminating this most fundamental knowledge throughout the world. The Institute is clearly demonstrating that the Vedic version is not a matter simply of "faith" or "belief", but is scientific in the strict sense of the term. Although many of its features may appear difficult to verify experimentally, others have direct implications concerning what we may expect to observe. Thus, this view should serve as a stimulating challenge to the truly scientific spirit to go beyond the very restrictive framework imposed on our scientific understanding of nature over the last two hundred years. Modern science began as an experiment to see how far nature could be explained without invoking God. But the purpose of Bhaktivedanta Institute is to introduce Vedic knowledge on a genuinely scientific basis for the first time in the history of this modern scientific age.

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Introduction

kṣetra-kṣetrajñayor jñānaṁ

> To understand the distinction between matter (the field or body) and life (spirit, or the knower of the field) is called knowledge.
> *Bhagavad-gītā* (13.3)

What is matter and what is life? What are their origins? Although these questions have been pondered time and again by many eminent thinkers in both the scientific and philosophical worlds, they have never been answered to everyone's satisfaction, and in spite of such great intellectual endeavor, they still remain quite controversial. Over the past two centuries, the ever increasing success scientists have experienced in their investigation of gross matter has led many people to expect that life will eventually be explained solely as a phenomenon of matter. At the present time nearly all serious attempts to understand the origin of life have been based on this fundamental presupposition, and this controversy is thus being conducted within very narrow limits.

In recent years, scientists of many disciplines, such as chemistry, biology, biochemistry, biophysics, geology, geochemistry, and space science, have devoted considerable attention to the study of the origin of life.[1-4] Virtually all these studies are based on the assumption that life is a manifestation of matter. Scientists in these areas proclaim that life originated from a random combination of molecules interacting under the influence of blind natural laws over a long span of time. These scientists postulate a primordial chemical soup of small and simple molecules, and they imagine that in the course of time, under the influence of chance and mechanical laws, life generated itself from these molecules.

Such speculations date back at least as far as the time of Darwin, who noted that we could not expect to observe life originating in this way today since already existing living organisms would interfere with the process:

> It is often said that all the conditions for the first production of a living organism are now present which could ever have been present. But if (and oh what a big if) we could conceive in some warm little pond with all sorts of ammonia and phosphoric salts, light, heat,

> electricity, etc., present, that a protein compound was chemically formed, ready to undergo still more complex changes, such matter would at the present day be instantly devoured, or absorbed, which would not have been the case before living creatures were formed.[5]

In Darwin's brief description we see nearly all the basic features of the "primordial soup" that serves as the starting point of modern theories of life's origin. The basic assumption is that living organisms consist of combinations of a few simple chemical compounds. This leads to the hypothesis that simple natural processes may have brought such compounds together under conditions suitable for their combination into more complex forms.

Once this simple initial condition is assumed, the next step is to introduce "chance." In the words of Jacques Monod:

> Chance alone is at the source of every innovation, of all creation in the biosphere. Pure chance, absolutely free but blind, is at the very root of the stupendous edifice of evolution: this central concept of modern biology is no longer one among other possible or even conceivable hypotheses. It is today the sole conceivable hypothesis, the only one that squares with observed and tested fact. And nothing warrants the supposition—or the hope—that on this score our position is likely ever to be revised.[6]

Chance and the interaction of molecules in accordance with simple physical laws are the only factors admitted as causes of change in modern scientific theories of nature. Although these causes seem inadequate, it is assumed that if a sufficiently long period of time is granted they will be capable of generating life in all its diverse and complex forms. Modern scientific inquiry into the origin of life thus adheres to the basic model illustrated in figure 1.

It is our thesis that this model is based on a fundamental misunderstanding of what life actually is. Before inquiring into the origin of a certain thing, it is essential to understand its fundamental nature. Otherwise, searching for its origin is totally meaningless. In this paper we will therefore attempt to understand the fundamental differences between matter and life before we inquire into the origin of life. We will argue that present scientific knowledge, especially that of physics and chemistry, is unable to fully explain the intricate phenomena associated with life. As the French physicist Louis de Broglie remarked, "It is premature to reduce the vital process to the quite insufficiently developed con-

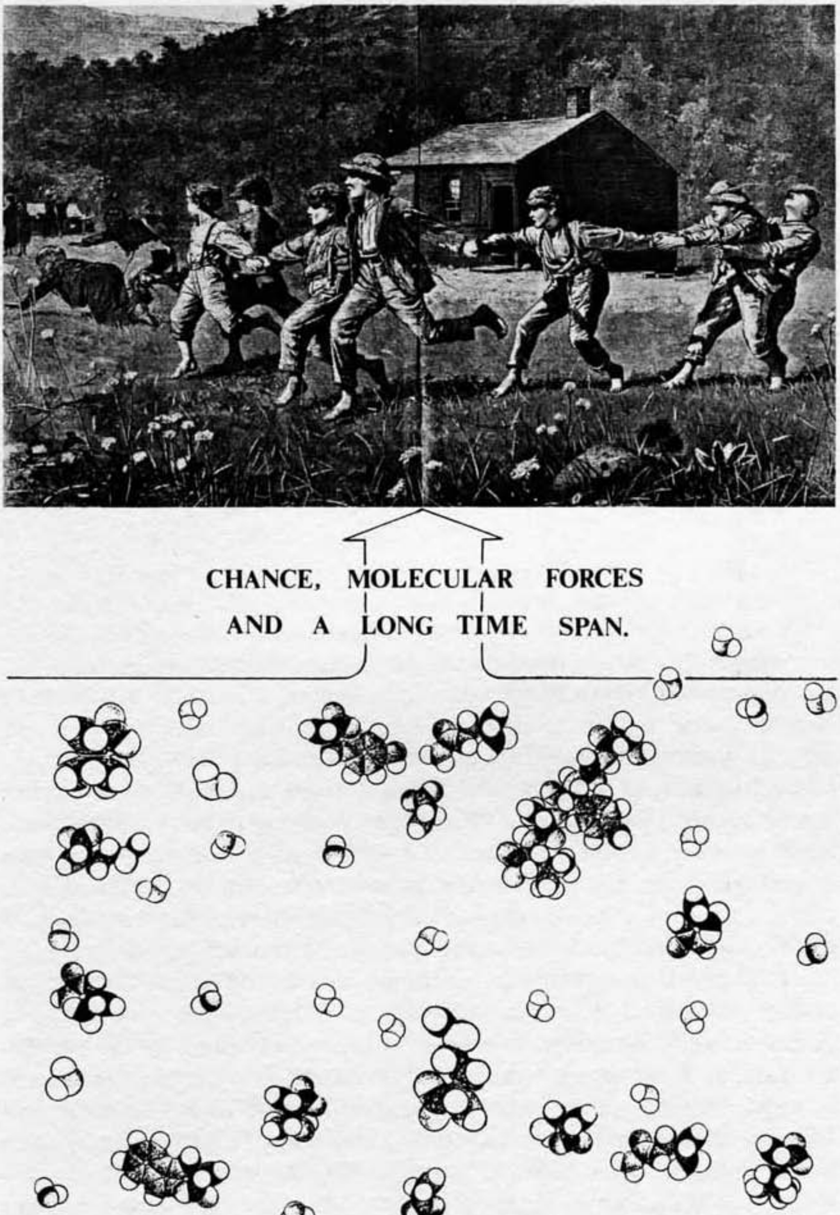

Figure 1. Is this the origin of life?

ception of 19th and even 20th century chemistry and physics."[7]

The physical sciences study "gross matter" only, although their results have been extrapolated to explain life. This reductionistic approach, however, has only indicated that the known physical laws of the present day are quite insufficient to account for the features of life. A new paradigm describing life and the laws of nature is needed. We will, therefore, propose an alternative scientific viewpoint (hypothesis). We do not intend to prove anything rigorously in this paper; rather, we will discuss the implications of this alternative viewpoint from a general perspective.

The Basic Features of the Absolute Truth According to Modern Science

The goal of scientific investigations is to seek the ultimate cause of all phenomena, governing matter, life, and the universe we perceive. In the course of history, many great scientists and philosophers have encountered considerable difficulties in this attempt, and many have acutely felt the limitations of the human intellect. Nonetheless, the search for knowledge is an inherent quality of the inquisitive mind, and it will go on.

In modern science, the concept of the ultimate cause, or the absolute truth, seems to be vaguely incorporated into the physical laws called the laws of nature. According to the theory of evolution, these laws of nature, and nothing else, have the power to select the most suitable forms from among different possibilities. We shall therefore briefly examine what these laws are.

The physical sciences—physics, chemistry, and mathematics—are devoted to the study of matter only. Copernicus, Galileo, Kepler, and Newton in the fifteenth, sixteenth, and seventeenth centuries were pioneers in the study of gross material phenomena, such as the planetary motions. These objects of study were found to obey certain mathematical regularities, which were termed "laws of nature," and the discovery of such laws became the target of scientific investigations. People were greatly impressed by the discovery of Newton's law of gravitation, Kepler's laws of planetary motion, and so on. Thus the more ambitious scientists came to think that all the phenomena underlying nature could be described by simple mathematical equations.

Among the more enthusiastic ones, the French scientist Pierre de Laplace proudly announced in the beginning of the nineteenth century that "all the effects of nature are only the mathematical consequences of a small number of immutable laws."[8] He believed that the universe was made up of atomic particles and that the exact condition of the universe at any one time could be given by specifying the exact positions and velocities of those particles with respect to a system of coordinates. He claimed that given these positions and velocities, he could, at least in principle, calculate the entire past and future of the universe from the laws of motion governing the particles. (Laplace, of course, could not have lived up to his boast, and any honest scientist might have thought that such big statements would not survive the test of time.)

From the art of alchemy in the Middle Ages, chemistry developed, and later it became one of the most significant fields of study in science. Antoine Lavoisier in the eighteenth century and John Dalton in the early part of the nineteenth laid the foundations for modern chemistry. They proposed that all gross substances were made up of elements or atoms, and since then the discovery of atomic elements has played a central role in chemistry. The discovery of the periodic law of chemical elements by the Russian scientist Mendeleev during the nineteenth century greatly impressed chemists and physicists all over the world. With this discovery, as well as with the discovery of many other laws, such as the ideal gas laws, the laws of dilute solutions, and the laws of thermodynamics, scientists became firmly convinced that exact laws underlying the phenomena of nature actually exist.

Similarly, since the discovery of the chemical structure of benzene by the German scientist Kekule in the nineteenth century, the study of organic structural chemistry has received greater and greater attention. Gradually many organic chemists became interested in the chemistry of living bodies and the different chemical reactions inside living cells. This branch of chemistry became known as biochemistry. More recently, molecular biology has developed as a specialized section of biochemistry.

If nature has laws governing matter, then it is quite conceivable that there must also be laws governing life. The tendency, however, has been to assume that the laws governing life are nothing more than the laws discovered for inanimate matter. Even though the biochemists have discovered chemical processes of ever increasing complexity and apparent sophistication within the living cells, the prevailing assumption has been that all phenomena of life can be accounted for by the same ordering principles that were discovered in the study of simple arrangements of gross matter.

Towards the end of the nineteenth century and the beginning of the twentieth, with the discovery of the fundamental particles—electrons, protons, etc.—the quantum mechanical equations were developed because the earlier equations of classical physics could not describe the behavior of these finer particles of matter. Chemistry and physics have since become more and more unified in the study of atoms and subatomic particles. For example, the earlier concepts of the valence bond theory of chemistry have been dealt with by the atomic and molecular orbital theories derived from quantum mechanics, giving better results in many cases. The well-known Woodward-Hoffmann rule of electrocyclic reactions is also an attempt in this direction.[9] In the present scientific community, a great many scientists are hoping that quantum mechanics will provide the necessary framework for the ultimate understanding of all the phenomena of nature. A summary of the quantum mechanical laws for chemistry is given in Figure 2.

The basic tenet that matter is measurable, calculable, and understandable in terms of physics and chemistry continues to guide the majority of scientists. This reductionistic approach of the physicists and chemists has been borrowed by the molecular biologists and molecular evolutionists, who faithfully assume that life can also be fully understood in terms of atoms and molecules

$$\text{(a)} \quad H\Psi = i\hbar \frac{\partial}{\partial t}\Psi$$

$$\text{(b)} \quad H =$$

$$\sum_n \frac{-\hbar^2 c^2 \frac{\partial^2}{\partial q_n^2} + \eta_n^2 q_n^2}{2} + \sum_k \frac{-\hbar^2 \nabla_k^2}{2m_k}$$

$$+ \sum_k \frac{i\hbar e_k}{m_k c} \bar{A}(\bar{Q}_k)\cdot\nabla_k + \sum_k \frac{e_k^2}{m_k c^2} |\bar{A}(\bar{Q}_k)|^2$$

$$- \sum_k \frac{e_k}{2m_k c} \bar{\sigma}_k \cdot \nabla_k \times \bar{A}(\bar{Q}_k) + \sum_{i>j} \frac{e_i e_j - G m_i m_j}{|\bar{Q}_i - \bar{Q}_j|}$$

$$\bar{A} = \sum q_n \bar{A}_n$$

Figure 2. The laws of nature underlying chemistry.

and their interactions. Thus, the well-known physicists Erwin Schrödinger[10] and Niels Bohr[11-12] expressed great hope that life could be completely understood in terms of physics. Similarly, molecular theorists of life such as Watson,[13] Crick,[14] and many others are absolutely convinced that life is a product of chemical reactions. Yet, an analysis of the equations listed in Figure 2 strongly suggests that this reductionistic position is not justified.

We will not discuss these equations in detail here. Readers interested in more details about these equations are referred to Monograph 3 of this series.[15] The first equation is the basic equation of motion, and is known as the Schrödinger equation. This is a second order partial differential equation. The second equation defines the Hamiltonian operator, or the sum total of the various kinetic and potential energy terms believed to be significant in chemical phenomena.[16] According to the viewpoint of the molecular biologists, the final cause underlying all the phenomena of life is represented by these mathematical equations. These equations may thus be taken as expressing the modern scientific view of the absolute truth, at least as far as life is concerned.

Yet if these equations are analyzed conceptually, they are seen to involve nothing more than some simple pushes and pulls between particles. There is a "free radiation" term, which can be visualized in terms of vibrating springs; a kinetic energy term; a term for the "push" between a charged particle and an electromagnetic field; a term for the "pull" between field and magnetic moment; and a term for the pushes and pulls between charged particles. The basic idea is illustrated in Figure 3.

Figure 3 sums up the interactions between molecules as seen in both the classical and quantum mechanical theories. In the quantum mechanical picture, the particles are described by "quantum waves," which give only a statistical estimate of their positions and momenta. It may even be said that in quantum mechanics the very idea of definite particles has become untenable. Nonetheless, the forces governing nature remain the same: just simple pushes and pulls. In summary, then, the modern scientific viewpoint reduces the absolute truth to nothing more than these pushes and pulls between particles: the universe consists of a vast number of particles interacting with one another by simple mechanical rules, having started from some chaotic arrangement. One might well wonder whether mere pushes and pulls can be solely responsible for all the diverse aspects of the world and ourselves that we experience in life. Are molecular biologists and molecular

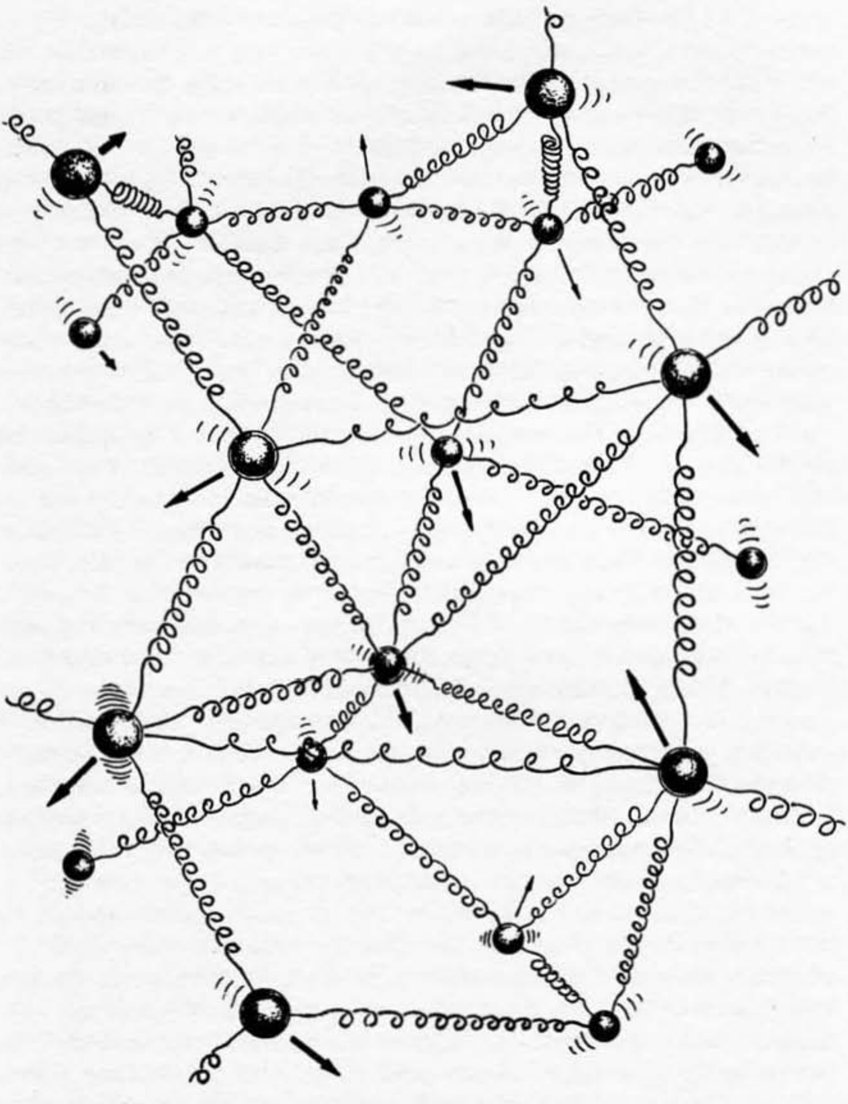

Figure 3. The essence of the laws of nature in modern science.

evolutionists going too far in claiming that life is nothing but a coordinated chemical reaction? What are the motivations and justifications for such a claim? The answers to these questions will be briefly discussed in the following sections.

Chemistry and Life: Is the DNA Molecule Life?

Until the nineteenth century, chemists thought that whatever happened in a living system could not be reproduced in the laboratory. In other words, inorganic matter was thought to be fundamentally different from the organic matter composing living material bodies. The prevailing view was that a non-physical vital energy was operating in the living system. In 1828, however, the German chemist Friedrich Wöhler announced the laboratory synthesis of urea from ammonium cynate, an inorganic compound. Urea is an end organic byproduct forming the major solid component of mammalian urine. Wöhler's synthesis of urea profoundly influenced the minds of chemists toward adopting a materialistic view of life. By the late 1850's, Pierre Berthelot reported the production of such organic compounds as alcohols, acetylene, methane and benzene from inorganic chemicals. Gradually, chemists began to think that there was nothing unusual about the organic world. Thus the way was paved for the view that life itself must be made up of chemicals. The announcement of Darwin's theory of evolution in 1859 lent further support to the concept that life was of material origin, a concept that has since remained dominant in both science and philosophy.

About one and a half centuries have passed since Wöhler's synthesis of urea, and indeed organic chemistry has advanced tremendously since that time. Synthetic fibers, synthetic rubber, synthetic dyes, chemotherapeutic agents, synthetic pesticides, synthetic glass and synthetic liquid crystals are some of the major products of synthetic organic chemistry.

Similarly, during the last fifty years or so, many advances have been made in the fields of cell biology and molecular biology. Chemists and biochemists have identified many chemicals such as lipids, proteins, deoxyribonucleic acid (DNA), ribonucleic acid (RNA), hormones and coenzymes inside the cells constituting living material bodies. Many scientists believe that the DNA molecule holds the ultimate explanation of life. It is their genuine hope that once this DNA molecule, the so-called master molecule, is assembled step by step from its constituent atomic elements—carbon (C), hydrogen (H), nitrogen (N), oxygen (O), and phosphorus (P)—their goal of synthesizing life in the test tube will be achieved. This will finally prove that life is, after all, nothing but a system of chemicals. But is the DNA molecule really the essence of life?

We would like to argue that no matter how complex they may be, all molecules or collections of molecules, including DNA, are *dead matter*. What scientists know and agree upon is that the majority of the molecules playing vital roles in living systems are extremely complex. This much is correct. We question only their further conclusion that if complex molecules can somehow be made from simple molecules (for example, proteins from amino acids, and DNA from nucleotides) then life will arise from these complex molecules by virtue of their proper combinations.

Let us briefly examine the chemistry of the cellular DNA molecule. It consists of two intertwined strands of complementary structures forming a regular double helix.[17] From X-ray crystallographic studies, the diameter of the helix is found to be approximately 20 Å, and each strand makes a complete turn every 34 Å (or every 10 nucleotides).[18] Strings made of alternate groups of phosphate and sugar (deoxyribose) form the backbone of the two strands. Each phosphate group links to deoxyribose, a five-carbon chain sugar. The sugar in turn links to one of two possible bases of purine (guanine or adenine) or two possible bases of pyrimidine (thymine or cytosine) through hydrogen bonds. Adenine (A) is always paired with thymine (T), and guanine (G) with cytosine (C), for conformational reasons and because of the donor-acceptor natures of the hydrogen bonding groups. As a stereochemical consequence of this strict base pairing, the two polynucleotide chains run in opposite directions. These are illustrated in Figure 4. Although hydrogen bonding between other base pairs is possible, it leads to nucleotide pairs which have the wrong external geometry and do not fit into the regular double-helical structure.

This strict requirement of base pairing is responsible for the systematic replication process of DNA. Geneticists commonly assume that DNA is the carrier of the genetic information of the cell. It duplicates itself before cell division to provide each daughter cell with a complete set of DNA molecules. DNA replication involves strand separation, and each separated strand forms the template for the condensation of a complementary strand. This is commonly called the Watson-Crick mechanism.

Descriptions such as this of DNA and its replication mechanism are commonly given as though they provided a complete description of the most fundamental processes of life—a final mechanical, step-by-step breakdown of these life processes into understandable chemical terms. However, this is far from true. An enormous gulf

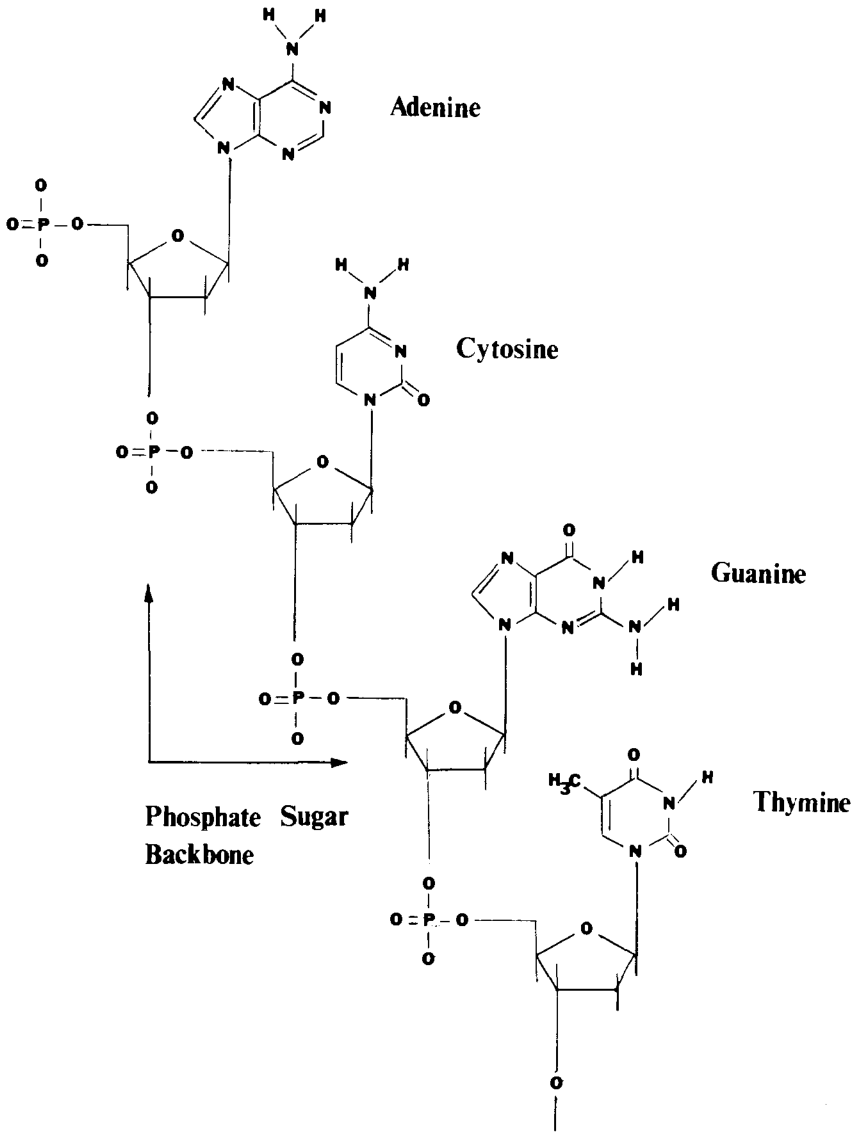

Figure 4. A section of the DNA molecule.

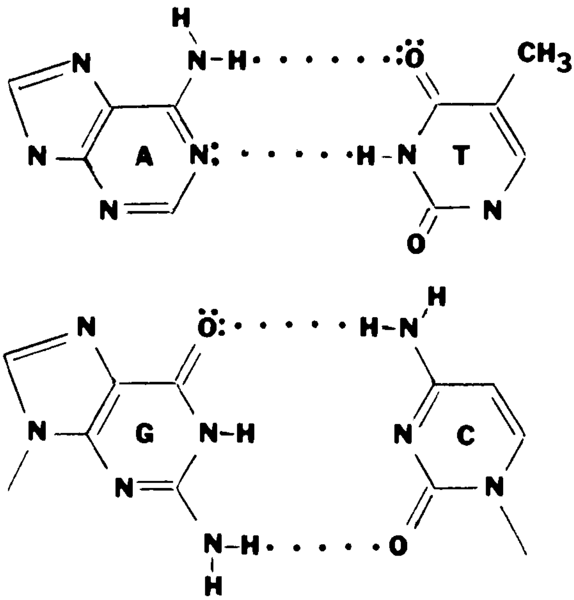

Figure 5. Hydrogen bonded base pairs in the DNA molecule.

lies between the few simple chemical facts known about DNA and the actual functioning of a cell. All that science actually knows about DNA are a few relations between inanimate chemicals. The gap between this knowledge and an actual chemical understanding of life is bridged only by faith.

To illustrate this, let us consider a few features of the cellular reproduction process. According to Watson, the replication and maintenance of DNA requires at least four different kinds of enzymes: endonuclease, exonuclease, DNA polymerase, and polynucleotide ligase.[19] These are all practically unknown at present. The one which seems to be best understood, DNA polymerase, is estimated to contain some 1,100 amino acid subunits, but the arrangement of these subunits is still unknown. It is thought that DNA polymerase is involved in the cellular replication of DNA. However, there is also evidence that this enzyme is involved in the repair of damaged DNA instead, and that in bacteria other, unknown enzymes in the cell membrane are required for replication.[20]

The replication process is thus very poorly understood. For example, the single chromosome of *E. coli* is thought to be a loop of double-stranded DNA some 500 times longer than the cell itself. Due to its spiral nature, this tangled loop must spin on its axis some 360,000 times in the course of a single replication, and the two loops must be neatly separated. In order to account for this, biochemists have postulated many different molecular mechanisms, but none of these are clearly understood.[21] This is just one of many examples that we could cite.

Although we may imagine that the cell is nothing more than an elaborate chemical machine, we actually do not at all know how this machine works. We have no idea how the large scale actions of a cell (what to speak of a multicellular organism) can be reduced to the reactions of molecules. Indeed, we do not even fully understand the chemical interactions of water molecules, and the operations of enzymes composed of 1,100 amino acids are certainly a mystery.

The assumption that the cell is a machine running according to simple push-pull laws is, therefore, simply a matter of faith. It may be imagined that thousands of reactions of the form $A_i + B_i \rightarrow C_i$ can combine to create an elaborate chemical automaton surpassing even the most sophisticated man-made computers. However, in contemplating this analogy we should consider that even the most detailed knowledge of the intricate functioning of a computer would be incomplete unless it entailed an understanding of the programmer. In like manner, it is quite possible in the context of current knowledge that other laws are involved in the operation of cells that are unknown to modern chemistry. The most that can be said at present is that the knowledge of the biochemists is a knowledge of chemical reactions; it cannot be claimed that it constitutes an understanding of life.

As a further example, consider the recently reported synthesis of the *E. coli* gene that codes for tyrosine transfer ribonucleic acid (tRNA).[22] This gene has only 126 nucleotides, and commercially synthesized nucleotides are used as the starting materials for the gene's synthesis. The nucleotides are chemically hooked to form di-, tri-, and tetranucleotides. These units are further chemically assembled into dioxyribooligonucleotide segments of 10 to 15 units. The segments that possess complementary base sequences are enzymatically connected with DNA ligase to form larger duplexes, which are themselves finally connected enzymatically to complete the synthesis. (It is not a total chemical synthesis, in the sense that the natural enzyme has to be used to join the larger units.)

A gene is taken as a fundamental unit of heridity. According to geneticists, everything from the color of rose petals to the shape and color of human eyes is determined by genes. It has been reported that the functioning of this artificial gene could be detected in a living cell. These are quite significant findings so far as chemical knowledge is concerned. They suggest the possibility that a geneticist will be able to manipulate genes chemically, replacing defective ones with healthy ones. This does not, however, demonstrate that genes are completely responsible for life. Rather, it simply indicates that cells make use of messages coded in chemical form, and that our technology may enable us to take advantage of this medium of information storage.

At this stage of scientific knowledge, all the experimental techniques and tools needed to synthesize most of the chemicals primarily found in living cells (for example, proteins, hormones, lipids, carbohydrates, vitamins and genes) are available. Yet scientists are nowhere near to constructing a complete "synthetic living cell" in the test tube. The great hope expressed by many molecular biologists about a quarter century ago (after the historic discovery of the double helical structure of DNA by Watson and Crick) seems to have faded away in the midst of new discoveries.

Indeed, the findings of the biochemists, far from proving that life is a chemical phenomenon, have strongly demonstrated that the present scientific understanding of life is inadequate. In Darwin's time the cell appeared to be little more than a simple bag of organic compounds that one might readily hope to describe in chemical terms. The enormous complexity encountered in recent biochemical investigations, however, has shown that this hope is unrealistic. Modern science is far from having understood the principles of life.

Szent-Györgyi, the Nobel-prize-winning chemist, thus remarked: "in my search for the secret of life, I ended up with atoms and electrons which have no life at all. Somewhere along the line, life has run out through my fingers. So, in my old age, I am now retracing my steps . . ."[23] This is the basic point we would like to emphasize. Atoms and molecules are lifeless. A gene or a DNA molecule is not life, and a protein molecule is not life. Indeed, we propose that a collection of these molecules is also not life. The recent announcement of Khorana's synthetic gene is not different from that of Wöhler's synthesis of urea in 1828 as far as our understanding of life is concerned.

Chemical Evolution: A Molecular Fairy Tale?

The theory of chemical evolution rests upon three assumptions: (1) The hypothetical primitive atmosphere must have been either reducing or neutral. This means that there was no free oxygen in the atmosphere in the earth's distant past. (2) Simple molecules like amino acids, purines, pyrimidines, and sugars were formed within this atmosphere under the action of ultraviolet radiation, electrical discharges, radioactivity, thermal energy, and so on. (3) In the course of time these molecules gave rise to protoproteins, protonucleic acids, and other protocellular components, which in turn gave rise to the so-called protocells and finally to the living cell.

We can briefly analyze these assumptions by purely scientific reasoning and argument. It is a foregone conclusion of many molecular evolutionists that the primitive atmosphere consisted of carbon (C) in the form of hydrocarbon such as methane (CH_4), nitrogen (N) in the form of ammonia (NH_3), oxygen (O) in the form of water (H_2O), and sulfur (S) in the form of hydrogen sulfide (H_2S). This was first proposed by Oparin,[24] the Russian evolutionist, and Urey,[25] the American physicist.

Based on this assumption, Miller[26] performed an experiment in which he passed an electric discharge through a gaseous mixture of methane, ammonia, hydrogen, and water vapor. Amino acids such as glycine, alanine, aspartic acid, and glutamic acid were observed as some of the components of the reaction products. Since amino acids are the smallest units of the protein molecule, Miller's experiment gave the molecular evolutionists great hope and encouragement for their idea of the chemical origin of life. They claim that such steps are the ones that will finally lead to life. However, to accept this claim as proven would be quite premature.

The idea of the primitive reducing atmosphere has received strong and serious criticisms from scientists of various disciplines. Their arguments suggest overwhelming drawbacks in the conjecture. Available data from geology, geophysics and geochemistry argue strongly against this idea. Abelson,[27] for example, argues that there is no evidence for the reducing atmosphere, and that ammonia would have quickly disappeared because the effective threshold for degradation by ultraviolet radiation is 2,250 Å. He suggests that a quantity of ammonia equivalent to the present atmospheric nitrogen would be destroyed in approximately 30,000 years.

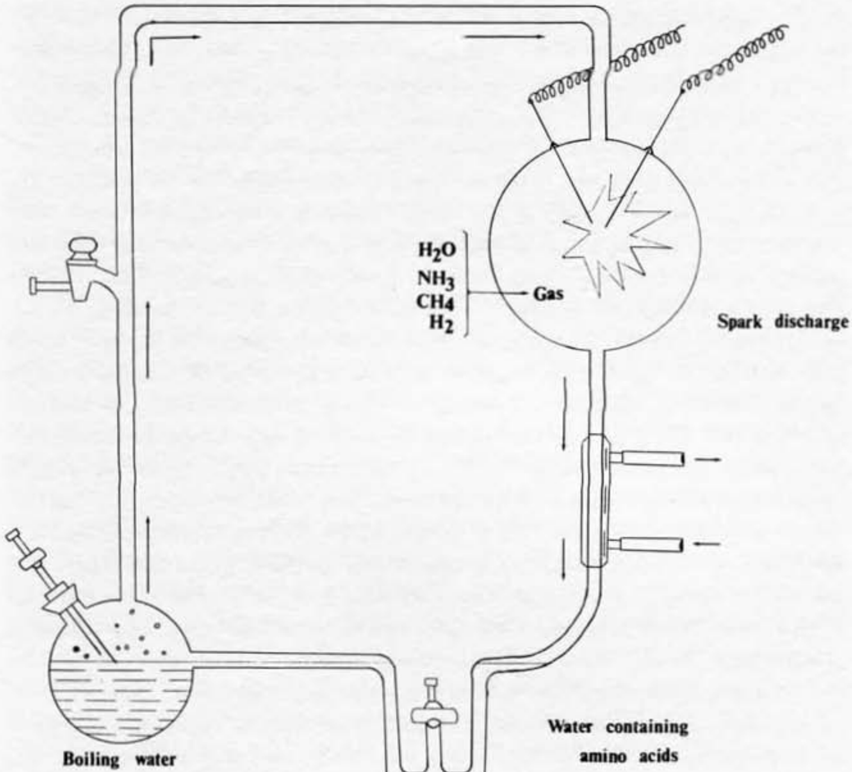

Figure 6. Miller's experiment.

Abelson has also suggested that if the primitive atmosphere contained large amounts of methane gas, geologic evidence for it should be available. Laboratory experiments show that irradiating a highly reducing atmosphere produces hydrophobic organic molecules that are absorbed by sedimentary clays. This suggests that the earliest rocks should have contained an unusually large proportion of carbon or organic chemicals. However, this is not the case.

From observations based on the stratigraphical record, Davidson[28] concludes that there is no evidence that a primeval reducing atmosphere might have persisted during much of Precambrian time. Brinkmann[29] shows from theoretical calculation that dissociation of water vapor by ultraviolet light must have generated enough oxygen very early in the history of the earth to create an oxidizing atmosphere.

In light of these arguments, the idea of a primeval reducing atmosphere does not seem tenable. Of course, this does not mean the end of speculation on the chemical origin of life. Although the reducing atmosphere has been by far the most popular, many other hypothetical primitive atmospheres have been proposed.

Thus, the gaseous mixture in Miller's experiment can be replaced by a mixture of carbon monoxide, nitrogen, hydrogen, and water vapor, giving comparable results and thus indicating that the carbon need not be in the form of hydrocarbon gas.[30] The molecular evolutionist Matthews[31] has advanced another theory about the possible formation of protein from hydrocyanic acid (HCN) gas. Electrical discharge experiments in a mixture of nitrogen, carbon monoxide, and hydrogen give HCN as one of the principal products.[27] HCN is an even more promising candidate as far as the formation of proteins, purines, pyrimidines, and other molecules of biological importance is concerned.

One can arrive at many alternative theories about the unknown past, and these can be criticized in turn. (For example, the two atmospheres just mentioned would not endure if the dissociation of water vapor generated substantial amounts of free oxygen.) But, where is the truth? We can only conclude that conditions (1) and (2) are shaky and speculative assumptions at best.

It has been claimed that the so-called coacervates of Oparin[32] and the proteinoid microspheres of Fox[33] are the protocells. We would like to examine what these words mean chemically. By definition, a coacervate is an aggregate of colloidal droplets held together by electrostatic charges. Coacervate formation has been observed when large molecules possessing hydrophobic and hydrophilic sites are dissolved in water. They consist of spheres or droplets separated from the bulk solution. It is believed that coacervates are the end product of the reduction of the hydration layer surrounding colloidal particles.

The phenomena of coacervate formation were first studied in detail by Bungenberg de Jong,[34] who demonstrated that coaceration is an effective technique for concentrating compounds of high molecular weight from aqueous solutions. The coacervate droplets are usually obtained by mixing solutions of proteins and other polymers—for example, solutions of gelatine and gum arabic, solutions of various proteins and nucleic acids, and so on. Oparin has reported that in the synthesis of polyadenine in vitro in a polypeptide solution, coacervate droplets begin to separate from the bulk solution as soon as the molecules reach a certain size.[35] He further draws the conclusion that non-specific polymerization of organic compounds must have taken place in the "primeval broth," leading to the formation of polypeptides and polynucleotides with randomly arranged monomeric residues in their chains. These polymers might have separated in the form of coacervate droplets, thus creating isolated systems where further evolution of organic polymers might have occurred that was not possible in the solution as a whole.

Oparin suggests that as soon as the polynucleotide chain reaches a certain size, even though it has a disorderly structure, it will interact with polypeptides and other compounds in the "primeval nutrient broth" and separate out from the solution in the form of coacervates. His reasoning is that although there could not be any selection of individual nucleotide molecules when they were in simple aqueous solution, the situation is different when they separate out as coacervate droplets after interacting with polypeptides. Because of the double helical character of the two complementary chains of polynucleotides, their inclusion in coacervate droplets (or protobionts) may have had certain effects on the polymerization of the amino acids in those systems. Those arrangements of amino acids unfavorable for the increasing catalytic activity of the polypeptides would be destroyed by natural selection. In this way, the structure of the protein-like polypeptides, and also that of the polynucleotides controlling their synthesis, may gradually have become more ordered and better adapted.

This may sound convincing until we look at the scientific facts. Coacervate formation is similar to the well-known chemical process called "salting out." For example, if the salt potassium chloride is added to a soap solution of potassium oleate, the phenomenon of coacervate formation is exhibited. The hydrocarbon chain of this soap molecule is less soluble in water. If increasing amounts of potassium chloride are added to a concentrated soap solution, two layers (phases) will form, and just before the separation of these distinct layers, oily droplets will appear. These are termed coacervates. The explanation is that the potassium chloride molecules compete with the water molecules in the potassium oleate solution, thus allowing the water molecules to separate from the hydrophobic chain of the oleate moiety. In chemical language these droplets are commonly known as spherical micelles. In aqueous solution, the nonpolar (hydrophobic) portion of the monomers reduce their contact with water and form the micellar core, while the polar (hydrophilic) portions remain in contact with water, forming roughly spherical micelles. In some nonaqueous (nonpolar) solvents the reverse phenomenon is observed. The polar groups of the monomers may become solvophobic, thereby forming the cores of the micelles. These are called inverted micelles. Cylindrical or lamellar aggregates also result in highly concentrated solutions. The two types of micelles are illustrated in Figure 7.

Monomers and micelles are usually in rapid dynamic equilibrium, and micelles are known to catalyze chemical reactions. Thus one can safely conclude that Oparin's coacervates simply exhibit the phenomena characteristic of micellar chemistry. Apart from his many "may have beens," he is simply describing a few physical properties of inanimate matter. Fox, Oparin's own colleague, has criticized his conjectures about these coacervates: "besides failing to answer the crucial primordial question, they are neither uniform nor stable."[36]

Fox, on the other hand, claims that his so-called protenoid is the "molecular missing link between prelife and life."[37] But, we can also show that this claim is completely erroneous and unfounded.

Proteinoids are formed by pyrocondensing dry amino acids.

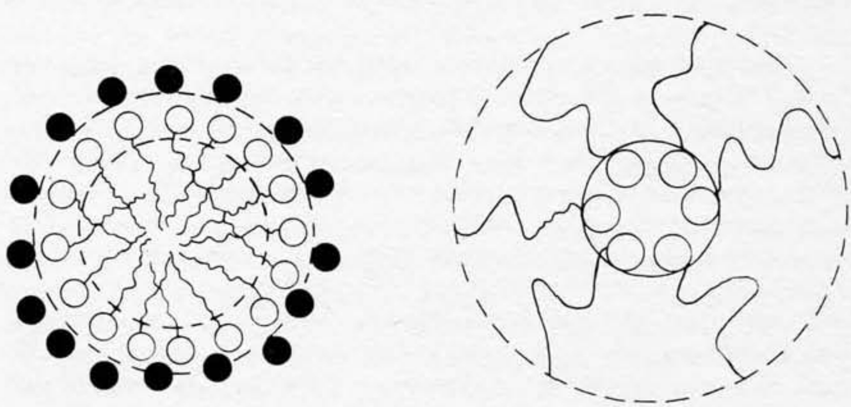

Figure 7. Spherical micelles.

The amino acids are heated at 140° to 180° C for about six hours. Only a sufficient proportion of one of the acidic amino acids, aspartic and glutamic acids, or of the basic amino acid, lysine, is required. The reaction mixture is treated with hot water and, after being stirred, the water-insoluble material is separated by filtration. When the filtrate cools down, the product precipitates as microscopic globules that Fox calls proteinoid microspheres. The molecular weights of the products can be as high as 20,000 when glutamic acid is heated with glycine. The proteinoids give all the color test results common to proteins. Fox further claims that the amino acid sequences in these proteinoids are highly nonrandom. Proteinoids catalyze like enzymes in hydrolysis of esters, decarboxylation, amination, and deamination reactions. He also claims that these proteinoids multiply by division in a manner similar to that of living cells.

We would like to suggest that all the above properties are simply the physico-chemical properties inherent in such molecules. They have nothing to do with the characteristics of living cells. Chemically, it is expected that when a mixture of amino acids is heated at elevated temperatures, polymers will be formed. These are the peptides, and they show the properties inherent in proteins. However, Fox's argument for the nonrandom sequencing of the amino acids in his reaction is quite objectionable. As a matter of fact, some of his own supporters accuse him of deception. Miller and Orgel in this respect remark:

> . . . the degree of nonrandomness in thermal polypeptides so far demonstrated is minute compared with the nonrandomness of proteins. It is deceptive, then, to suggest that thermal polypeptides are similar to proteins in their nonrandomness.[38]

They continue by saying:

> The importance of these thermal syntheses in prebiotic chemistry is a very controversial matter. We do not believe that they were very important because we doubt that polypeptides could have been synthesized in large quantities at the surface of the earth by thermal reactions of the kind so far demonstrated.[39]

So many unique events and conditions have to be simultaneously fulfilled in Fox's model of proteinoid formation that it is very doubtful whether many chemists will ever take it seriously.

First of all, the temperature specified by Fox for the heating of the amino acids is very unlikely to occur on the surface of the earth. Although the temperature in some hot springs may rise to 140° or 180° C, such reactions are extremely improbable. Fox's conditions require that the amino acids be in the right place and also be dry. The polymerization reaction of amino acids does not take place in the presence of water. In fact, the reverse reaction will be favored, and the polypeptides will be completely hydrolysed to amino acids under such conditions. The thermodynamic free energy of this condensation reaction is about 2.00 to 5.00 kcal/mole, which means that the reaction is very unfavorable towards the product side.

$$\text{HOOC-CHR-NH}_2 + \text{HOOC-CHR}'\text{-NH}_2 \rightleftharpoons$$
$$\text{HOOC-CHR-NH-CO-CHR}'\text{-NH}_2 + \text{H}_2\text{O}$$
$$\Delta G = 2\text{-}5 \text{ kcal/mole}$$

The other possibility of temperatures as high as 140° to 180° C is in volcanoes. Here again the conditions are not favorable for the production of the polypeptides. In volcanoes the temperature of molten lava is about 1,200° C, which will completely destroy the amino acids. It should also be mentioned that ultraviolet radiation, being a very powerful source of energy, can not only create organic molecules but also destroy them—especially macromolecules such as proteins and nucleotides.

Finally, from a purely chemical point of view, Fox's proteinoids may be expected to possess some catalytic activity as general acid-base catalysts according to a catalysis law of the Brönsted type. This has nothing to do with the true nature of a living cell and, therefore, with life. One can see that all these claims amount to no more than *molecular fairy tales.* They are like taking a rope to be a serpent. Thus, from the above evidence, we can see that assumptions (2) and (3) have no valid scientific foundation.

Chemical Evolution:

The Role of Chance and the Long Time Span

It is often claimed in books on the origin of life that life is bound to evolve from chemicals, given sufficient time. The idea is that even though an event may be highly improbable, if one waits long enough it is bound to happen. As one popular account has it,

> The odds against the right molecules being in the right place at the right time are staggering. Yet, as science measures it, so is the time scale on which nature works. Indeed, what seems an impossible occurrence at any one moment would, given untold eons, become a certainty.[39]

Therefore, we shall briefly examine how chance applies to the formation of biological macromolecules.

Let us consider the probability of forming a particular chain of amino acids at random. Since there are 20 kinds of amino acids in living bodies, there are some 20^N possible proteins composed of N amino acids linked in a chain. Of these, there are

$$\binom{N}{N/10} 20^{N/10}$$

chains equal to a particular given chain for all but 10% of its amino acid links. If we pick an N link chain completely at random, the probability that 90% of it will match our given chain is therefore,

$$P = \binom{N}{N/10} 20^{-9N/10} \approx \frac{10^{-N}}{\sqrt{N/2}} \qquad (1)$$

Figure 8 illustrates these probabilities for a number of proteins found in living cells. These probabilities show that it is extremely unlikely that a particular protein will form by chance, even if we allow for 10% of its amino acid subunits to be in error. These conclusions are elementary and well-known. However, numbers such as 10^{-52} and 10^{-246} are not very meaningful by themselves. In order to see what these numbers mean, let us consider them in the context of a model for the chemical origin of a proto-

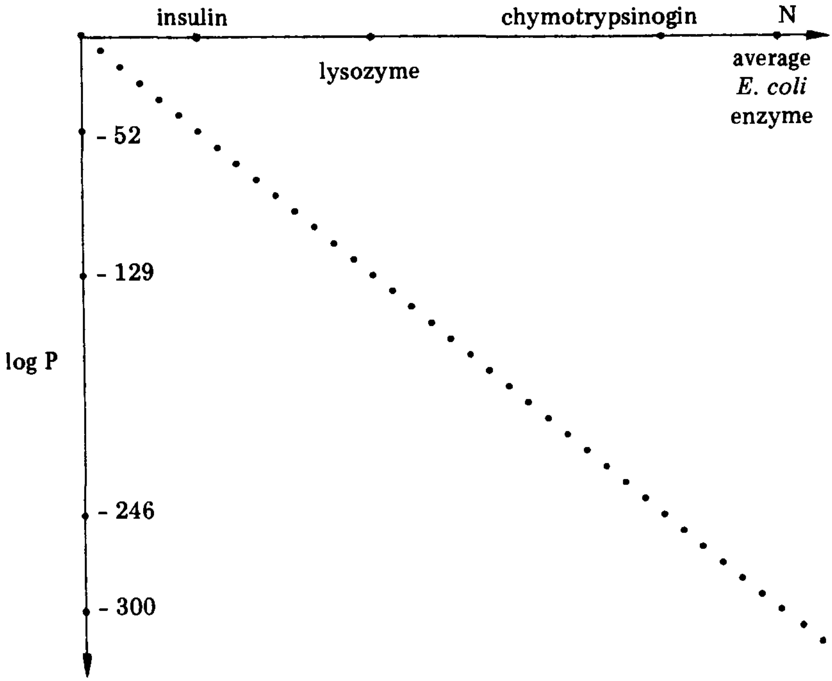

Figure 8. The probability, P, of randomly picking a specific protein of N amino acids with an error of 10% or less.

cell. We would like to show that the necessary molecular components for a functioning protocell cannot be expected to come together by chance, even if thousands of billions of years are allowed.

For our model, let us postulate a "primordial soup" one kilometer thick, covering the entire surface of the earth. Let us suppose that this soup is so packed with protein molecules that there is an average of one protein in each 20 x 20 x 25 Å^3 box throughout its entire volume. We shall assume that these proteins are continuously being created, destroyed, and moved about, so that their arrangement changes in each millionth of a second. We shall also assume that these arrangements are completely random and disorderly. This model is intended to provide more random arrangements of molecules per unit time than could ever have been produced in any actual situation on the primordial earth. As such it takes into account both the random creation and the random diffusion of molecules.

We are interested in seeing whether or not the necessary initial constituents of a self-sustaining protocell could be expected to come together by chance in this soup over a long period of time. In order to do this, we shall first review the molecular composition of living cells. The distribution of molecules in a cell of the bacterium *Escherichia coli* is outlined in Figure 9.[41] We can see from this table that many thousands of very large protein molecules are involved in the metabolism of *E. coli*, even though this is one of the smallest independent living cells. The average size of these proteins is about 300 amino acid subunits.

An example of the function of such complex proteins in cells is the process of biosynthesis of L-isoleucine illustrated in Figure 10. In this process, L-isoleucine is produced from L-threonine in five steps.[42] Each step is catalyzed by a specific large protein molecule called an enzyme. Such enzymes have the property of greatly accelerating a particular chemical reaction, while not affecting other reactions at all. They also must be capable of interacting with other particular molecules to regulate their activity. In this example, the enzyme L-threonine deaminase, catalyzing the first step in the chain, is sensitive to the presence of the product molecule L-isoleucine, produced four steps later. When the concentration of L-isoleucine reaches a certain critical level, this enzyme ceases to function, insuring that no more than the necessary amount of the product is formed. We can thus see that a precise and integrated system of molecular interactions analogous

Cell Component	Approximate Number/Cell	Different Kinds
Water	4×10^{10}	1
Inorganic ions	2.5×10^{8}	20
Carbohydrates and precursors	2×10^{8}	200
Amino acids and precursors	3×10^{7}	100
Lipids and precursors	2.5×10^{7}	50
Nucleotides and precursors	1.2×10^{7}	200
Proteins	10^{6}	2000 to 3000
DNA	4	1
tRNA	4×10^{5}	40
mRNA	10^{3}	1000

Figure 9. The distribution of molecules in *Escherichia coli.*

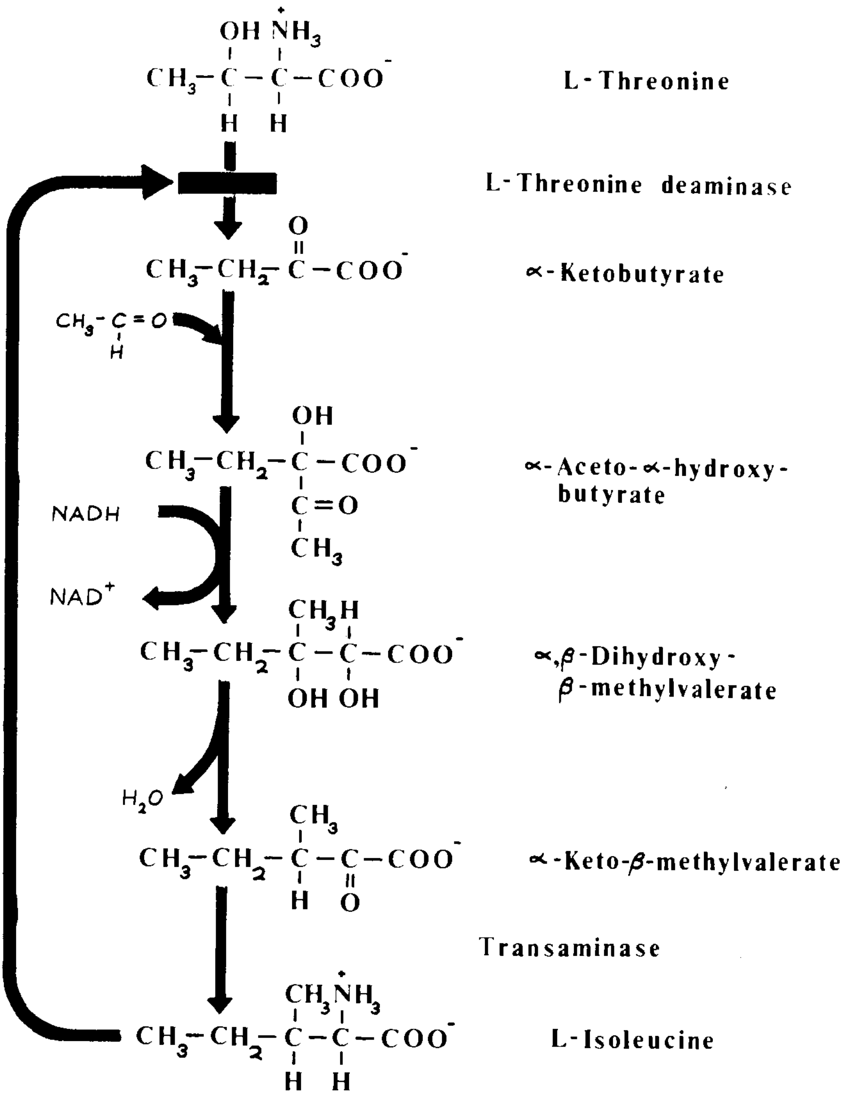

Figure 10. Enzymatic regulation in cellular synthesis.

to a sophisticated computer program is necessary for the harmonious functioning of a self-sustaining metabolic system.

Another example is the system of enzymes involved in the replication of DNA. Here we are indeed faced with an intriguing problem. In order for DNA to replicate, certain highly complex enzymes are needed which are themselves encoded in DNA.[43]

How could such an arrangement get started? These are both examples in which many interdependent cellular components interact in such a way that the successful functioning of the whole cannot take place unless all of the components are present.

We do not know whether any kind of self-sustaining metabolizing unit is possible with substantially fewer and smaller molecules than a small bacterial cell like *E. coli*. Yet, for the sake of argument, let us consider a protocell made with protein molecules no larger than insulin. We choose insulin for the sake of clarity. Its structure has been analyzed, and with only 51 amino acid subunits, it is one of the smallest known proteins. We should note that the arrangement of the amino acids in insulin has to be very precise in order for it to function properly in the human body. The British scientist Sanger demonstrated that a very slight modification of any one of its molecules—for example, the removal or modification of any one of the amino acids—would spoil its activity as an anti-diabetic agent.

Even though a protocell might be less efficient than modern organisms, it would have to have a sufficiently sophisticated metabolic apparatus to enable it to continue functioning for a long period of time—long enough to give it the opportunity to evolve further by the accumulation of mutations and adaptations. Since many highly specific protein molecules are evidently needed in the functioning of present-day living cells, it stands to reason that similar molecules should be required in our hypothetical protocell.

Let us compute the probability that k specific proteins of N amino acid units apiece will appear in a small volume in our "primordial soup" at some time in 1,000 billion years. We shall take this volume to be about 10^{12} Å^3, the approximate volume of an *E. coli* cell. Neglecting insignificant terms, this probability is no more than

$$P_r \leqslant 1.6 \times 10^{61} \ (10^{10} P)^k/k! \qquad (2)$$

where P is the probability for the random formation of one protein of N amino acids.[44] If we use equation (1) for P and let N = 51, the number of amino acids in insulin, we find that

$$P_r \leqslant 10^{-21} \qquad (3)$$

even for k = 2. This means that two specific molecules the size of insulin could not be expected to occupy by chance the same volume of *E. coli* size anywhere in our super-concentrated soup at any time in billions of billions of years.

Even if we let N = 20, we find the similar probability of finding six specific peptides of 20 amino acids apiece in one volume the size of *E. coli* to be

$$P_r \leqslant .02 \tag{4}$$

This probability indicates that there is only one chance in 50 for these six peptides to be found together even once in a thousand billion years.

These figures, and others which can be easily calculated, show that chance cannot be expected to bring together the initial components of a protocell, even though thousands of billions of years are allowed for this process. We should point out that these calculations are by no means limited to proteins. They also apply to the formation of the specifically ordered nucleotide chains that are believed to have been essential components of the protocells.

It is ironic that even though these calculations are both elementary and familiar to many scientists, students are nonetheless taught in schools and colleges that life has arisen by a chance combination of molecules over a long span of time. Evidently, however, chance will not suffice; some other cause must be invoked to account for the structures of living cells. The only alternative available within the limits of modern science is to suppose that the simple push-pull laws of molecular interaction can somehow bring cells together out of chaos. But how are they to do this? No explanation ever proposed has stood up under scrutiny. Yet the teaching that life has arisen from matter continues without reservations.

Chemical Evolution: Intellectual Dishonesty

Many scientists of the materialistic evolutionary persuasion seem to lack a genuine spirit of intellectual honesty. But unfortunately their theory is on the rise and their influence is strong. They are widely respected as authorities, although they are spreading false knowledge in the guise of science. Such dangerous dishonesty cripples the spirit of true knowledge and misleads young intellects.

Many of the evolutionary scientists try to push forward their own theories, right or wrong. For example, even though Fox's theory of microspheres has been extensively criticized by his own colleagues as unsound, it has nonetheless been widely advertised as a demonstration of the origin of life. In introductory texts aimed at college and high school students one can find glowing accounts of this theory devoid of any critical commentary.[45]

The same thing can be said for practically every aspect of the modern scientific account of life. The biochemical accounts of DNA and RNA are often presented in popular literature as though all the significant aspects of their functioning were clearly understood in chemical terms. This literature stems from the professional scientists who work in these fields. Yet, if one peruses their more technical work, as we have briefly done, one finds a labyrinth of difficulties and mysteries. It is plain that the chemical theory of life has not been established, but one must look very far through the literature of modern science to find a frank admission of this.

Thus, although evolution is far from proven, many scientists speak as though it were an established fact. George Wald says:

> Surely this is a great part of our dignity as men, that we can know, and that through us matter can know itself; that beginning with protons and electrons, out of the womb of time and the vastness of space, we can begin to understand; that organized as in us, the hydrogen, the carbon, the nitrogen, the oxygen, those 16 to 21 elements, the water, the sunlight—all, having become us, can begin to understand what they are, and how they came to be.[46]

The conclusion drawn is bold, but the evidence is too weak to be scientific.

There is, unfortunately, evidence that many scientists are at least as interested in using propaganda and political pull to indoctrinate people as they are in the pursuit of genuine knowledge. It is often stressed that the theories of science stand on the basis of evidence and reason alone, and that these theories are always open to challenge. Yet we have recently seen over 150 prominent scientists signing a petition "affirming evolution as a principle of science," and declaring that, "There are no alternative theories to the principle of evolution . . . that any competent biologist today takes seriously."[47] Statements such as this reflect a marked lack of openness in modern scientific circles to the serious discussion of alternatives to prevailing views.

They also reveal a willingness to use theories belonging in the realm of conjecture and speculation as tools for the manipulation of people's behavior and thinking. Thus, the Nobel-prize-winner Francis Crick states:

> Once one has become adjusted to the idea that we are here because we have evolved from simple chemical compounds by a process of natural selection, it is remarkable how many of the problems of the modern world take on a completely new light. It is for this reason that it is important that science in general, and natural selection in particular should become the basis on which we are to build the new culture.[48]

What will this new culture be? Obviously it will be a molecular culture that will produce men like Aldous Huxley, who said,

> I had motives for not wanting the world to have meaning . . . For myself, as, no doubt, for most of my contemporaries, the philosophy of meaninglessness was simultaneously liberation from a certain political and economic system and liberation from a certain system of morality.[49]

Motives such as these can also be seen in such building blocks of the "new culture" as *The Origin of Johnny*[50] and *Biology Today*.[51] These books, the first intended for young teenages and the second for beginning college students, both present a strictly molecular view of life and conclude by advocating its logical corollary: a philosophy of complete hedonism.

In view of the consequences of such a philosophical choice, it is unfortunate that it should be given such strong support through the uncritical propagation of highly questionable theories among innocent people. We can only conclude that in studying the origin of life, many scientists have failed to act in the true spirit of knowledge. One could appreciate their efforts more if the findings were presented more honestly.

Molecules lack inherent purpose and meaning. Yet we give value to life. A reciprocal feeling of love and care exists among people and among other living entities. Parents think about their children; a nation thinks about the welfare of its subjects. Great sages think about the welfare of all living entities—starting from an ant up to man. There can be no value without purpose and meaning. However, the doctrine of the chemical nature of life reduces life to complete meaninglessness. Since this is contrary to the truth, it generates a sense of emptiness and unhappiness in one's subliminal mind. This is vividly illustrated in the case of Darwin, the father of the doctrine of evolution. He developed, in his own words, a "curious and lamentable loss of the higher aesthetic tastes."[52] He expressed this loss in his autobiography:

> I have said in one respect my mind has changed during the last twenty or thirty years. Up to the age of thirty, or beyond it, poetry of many kinds, such as the works of Milton, Gray, Bryon, Wordsworth, Coleridge, and Shelley, gave me great pleasure, and even as a schoolboy I took intense delight in Shakespeare . . . I have also said that formerly pictures gave me considerable, and music very great delight. But now for many years I cannot endure to read a line of poetry: I have tried lately to read Shakespeare and found it so intolerably dull that it nauseated me. I have also almost lost my taste for pictures or music . . . My mind seems to have become a kind of machine for grinding general laws out of large collections of facts, but why this should have caused the atrophy of that part of the brain alone, on which the higher tastes depend, I cannot conceive . . . . . . The loss of these tastes is a loss of happiness, and may possibly be injurious to the intellect, and more probably to the moral character, by enfeebling the emotional part of our nature.[53]

It is ironic that Darwin should have expressed these thoughts. Why should man, if he is a product of molecular pushes and pulls, worry about happiness or unhappiness? Why should people busy their minds about moral and ethical values? Why should it be necessary to establish educational institutions? Why do problems like those of disease, drugs, alcoholism, smoking, violence, crime, abortion, and euthanasia bother our minds?

Educated people have shown a renewed concern for professional ethics and human values.[54] This is a direct challenge to the

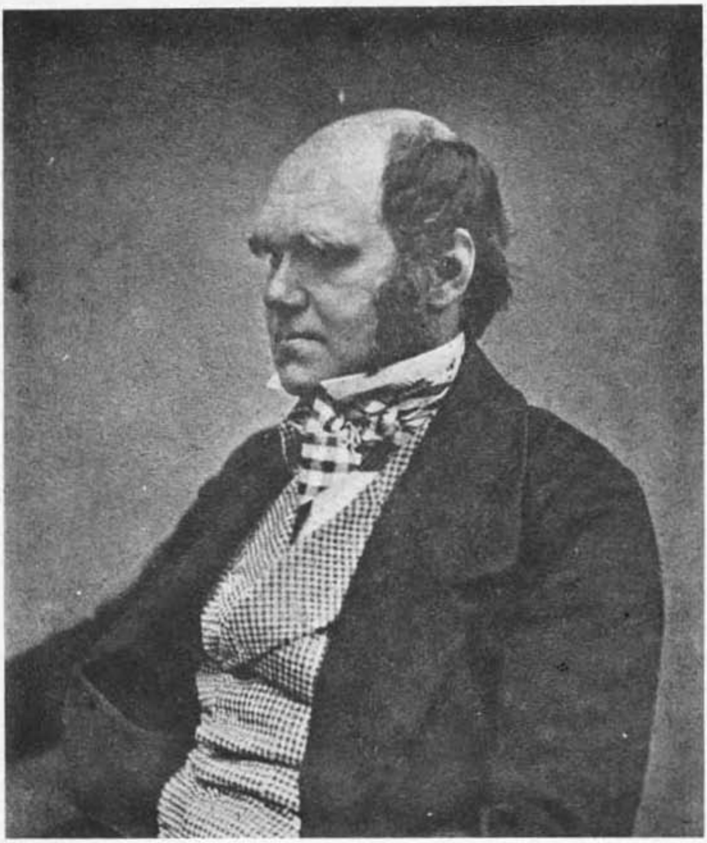

Figure 11. Charles Darwin.

doctrine of the molecular character of life. Great concern has been expressed over: the chlorofluorocarbon controversy—skin cancer may be caused by the depletion of the ozone layer in the stratosphere; the ban of synthetic sweetners—cyclamate and saccharin, for example, may cause cancer; recombinant DNA research—when a gene is transferred from one organism to another, harmful and uncontrollable organisms might escape. The first Bioethics Center was formed at Georgetown University, Washington, D.C., in 1971 for concerned scientists who wanted to study perplexing biomedical problems like genetic engineering and organ transplants.[55] A growing concern has developed over bioethical problems such as *in vitro* fertilization of human eggs and their implantation, cloning, and so on. Because of such concerns, the Illinois Institute of Technology recently set up a Center for the Study of Ethics in the Professions.[56] These are new additions to academic curricula. If humanity is a product of molecular pushes and pulls, there is no reason why people should be concerned about the moral and ethical values of life. But every sensible person knows that there is value in life. Life per se is full of meaning and full of purpose.

Experimentally Observed Facts Concerning Life

The study of metabolic cellular pathways and the synthesis of a large number of molecules found in the living machinery have so far demonstrated that there is still something missing in our understanding of life. The synthesis of amino acids from a mixture of methane, ammonia, hydrogen, and water molecules by electric discharge, as reported by Miller, represents a merely chemical process. It in no way comes close to solving the riddle of the origin of life. Yet excitement over this simple experiment is so great that those who profess belief in chemical evolution have concluded that such steps are the ones that will finally lead to the evolution of a living cell. We do not, however, even know what a cell really is in its complete detail. It has been estimated that there may be as many as some 200 trillion molecules in a single cell, all executing thousands of coordinated reactions with precise timing and function.[57] Each step is performed in a specific order, keeping clear of other steps so as not to upset the balance of the reactions.

An example is the biosynthesis of L-isoleucine from L-threonine. We have noted that if the end product is supplied from an outside source, the synthetic steps are immediately stopped, the first step having been inhibited by the binding of the enzyme L-threonine deaminase with L-isolecine. This is referred to in biochemical language as a feedback inhibition mechanism. Likewise, in the transcription of DNA to RNA, and the translation of RNA to proteins, all the steps follow directed instructions. What makes a living cell perform all these seemingly purposeful chemical reactions? What are the chemical theories or principles that can explain such apparently conscious acts even at molecular levels? What is the wave function that can explain such phenomena?

One of the authors asked Stanley Miller, the molecular evolutionist, during one of his series of lectures at the University of California, Irvine, on the origins of life, "Suppose you were given all the necessary cellular chemicals. Could you create a living cell?" His immediate answer was, "I do not know."[58] The point is that if this experiment cannot be demonstrated, molecular evolutionists cannot honestly claim that life has arisen from molecules. As explained earlier, a molecule, no matter how orderly and precisely arranged, is lifeless. To make the artificial gene work, the help of a living cell is required. All the molecules, including DNA, are only vehicles to carry out an instructed message, just like the running of a watch. But are the watch and the watchmaker the same?

Let us now turn to some explicit contemplative questions. What is that molecular operation that makes us appreciate a beautiful landscape or listen to a nice symphony orchestra? What is that molecular operation which makes us feel joy upon seeing a close friend or relative after a long time, or sad when losing a near and dear one? What is that molecular operation which makes a squirrel sense its ability to jump from one branch of a tall pine tree to another with perfect timing and accuracy? What is that molecular operation which makes the Pacific northwest salmon undertake the mysterious and dramatic odyssey of swimming upstream hundreds of miles in the face of many obstacles just to spawn and then die? What is the molecular operation which directs the tiny sandpiper to follow the course of a subsiding wave along the seashore with hundreds of quick steps to find its food? What is that molecular operation which makes the cuckoo lay its eggs in the nests of other birds as a meaningful trick? What enables the Nile crocodile, whose jaws can crush the femur of a buffalo, to pick up its egg gently enough not to break it, freeing the hatchling without harming it?[59] What are those molecules which discriminate between such contrasting but spontaneous conscious acts? And finally, what is that molecular operation which makes thoughtful scientists come together to discuss the value of knowledge and the goal and meaning of life? Are all of these due to molecules? Is there any molecular operation or any multidimensional quantum mechanical equation that can describe these wonderful phenomena of life?

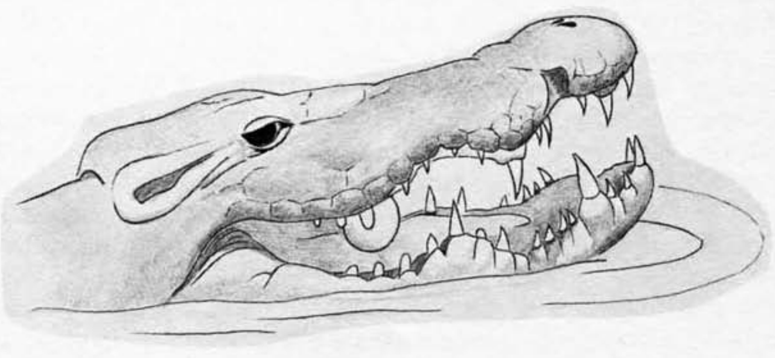

Figure 12. A Nile crocodile freeing its young from the egg.

On the human level there are so many subtle traits of personality—for example: humility, stability and self-control, honesty, tolerance, responsibility, cleanliness, love and so on. Are there any molecular mechanisms that can turn off and on to produce all these unique symptoms?

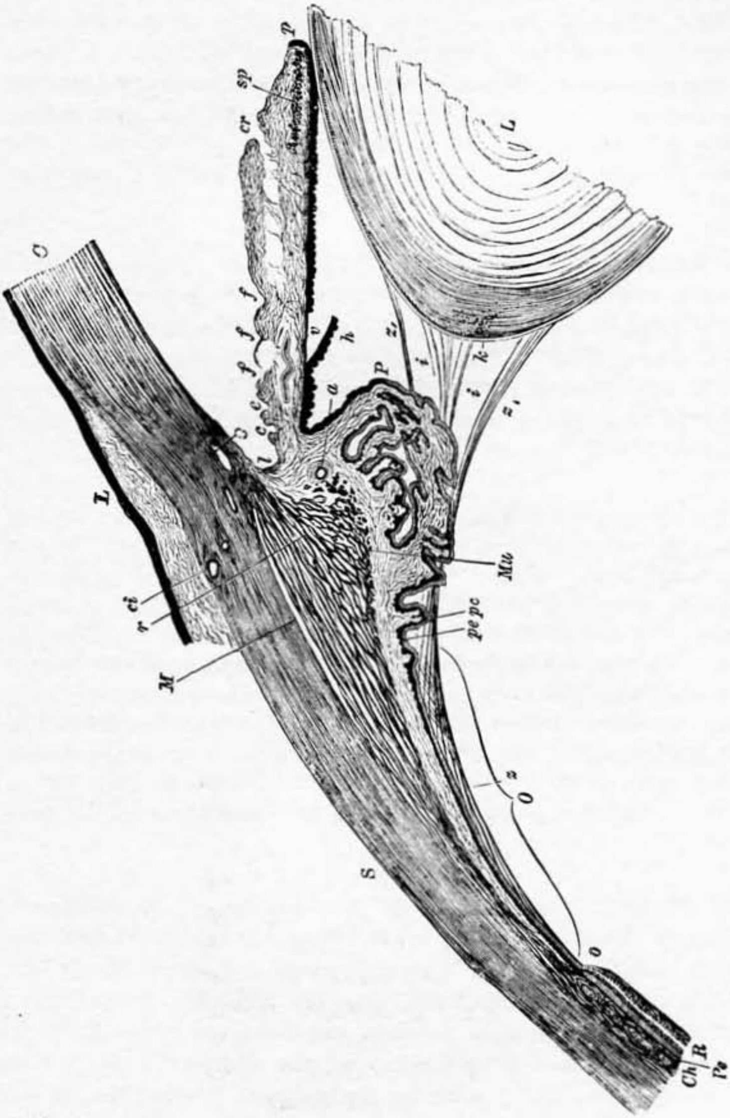

Figure 13. The structure of a human eye.

There are innumerable examples one may cite. We encounter marvels of life on so many levels, and the theorists of evolution cannot even think of touching these points. Darwin himself encountered insurmountable difficulty in conceiving how an eye could evolve. The fine, intricate details of the colorful feather in a peacock's tail were also impossible for him to explain. He thus remarked:

> I remember well the time when the thought of the eye made me cold all over, but I have got over the complaint, and now small trifling particulars of structure often make me very uncomfortable. The sight of a feather in a peacock's tail, whenever I gaze at it, makes me sick.[60]

Sometimes in human experience mental events happen suddenly and without apparent antecedents. Fine poetry comes from a poet's thought; the solution to a difficult mathematical riddle is revealed like a flash in the mind of a mathematician; an intricate chemical structure is revealed in the mind of a chemist; a whole symphony is inspired in the mind of a composer. Consider the experience of the famous composer Mozart:

> When I feel well and in good humor thoughts crowd into my mind as easily as you could wish. Whence and how do they come? I do not know and I have nothing to do with it. . . . Once I have my theme, another melody comes, linking itself with the first one, in accordance with the needs of the composition as a whole . . . Then my soul is on fire with inspiration, if however nothing occurs to distract my attention. The work grows: I keep expanding it, conceiving it more and more clearly until I have the entire composition finished in my head though it may be long . . . It does not come to me successively, with its various parts worked out in detail, as they will be later on, but it is in its entirety that my imagination lets me hear it.[61]

Are we to suppose that these phenomena are nothing but the products of chance and simple pushes and pulls? In Mozart we see a unique ability not present in any other members of his family. (Mozart's father, for example, was an ordinary musician.) If a biochemical machine was present in Mozart's brain that could generate symphonies effortlessly, where did this machine come from? If a human being were to design such a machine, he would certainly have to adjust many delicately interrelated variables, and this would require great intelligence and perserverance. Are we to suppose, then, that a random mutation of a gene or a chance combination of genetic alleles was able to produce such a machine? (We should note that the chance that a pattern will form randomly goes down exponentially with the number of variables entering into the pattern.) Or are we to suppose that by Coulomb's law and the spin-orbit interactions, such a machine will just naturally pull itself together, given enough time?

Limitations of the Laws of Nature

There is every reason to believe that simple push-pull laws are insufficient to account for all the effects of nature. The idea that they are known to be sufficient can easily be seen to be an illusion, for the quantum mechanical equations of Figure 2 can be solved exactly only in very simple situations. Even the calculations of the equilibrium state of a diatomic hydrogen molecule are very difficult and can be approached only by approximations requiring extensive computer calculations.

Yet the diatomic hydrogen molecule has only four particles—two electrons and two protons. For larger numbers of particles, practically nothing can be said about the solutions to the quantum mechanical equations. Glycine, the smallest amino acid, has 85 particles (if we count each nucleus as a unit), and cellular proteins contain hundreds of amino acids. It is therefore nothing but an article of faith that only the known laws of physics can account for life.

In addition, if we scrutinize the mathematical system of modern physics, we find serious contradictions and discrepancies suggesting that these laws are not adequate to describe even the phenomena of inanimate matter. These contradictions involve the most basic features of the theory of quantum mechanics, and concern the relation between its deterministic equations (the Schrödinger equation) and its statistical interpretation.

To enter into these matters here would take us too far afield. (An extensive treatment of this subject is provided in Monograph 3 of this series.[62]) However, we should note that many eminent scientists have held strong reservations about this theory. Einstein in particular felt that the theory was quite unrealistic. He remarked:

> The Heisenberg-Bohr tranquilizing philosophy—or religion?— is so delicately contrived that, for the time being, it provides a gentle pillow for the true believer from which he cannot very easily be aroused. So let him lie there.[63]

It is thus premature for biologists and biochemists to select this theory as the ultimate foundation for their understanding of life. In this section, we shall briefly present some mathematical findings directly indicating that simple laws cannot give rise to the complex structures we see in living organisms. These conclusions imply that the standard view of the laws of nature is incomplete; there must be many laws operating in nature which cannot be reduced to combinations of known physical interactions.

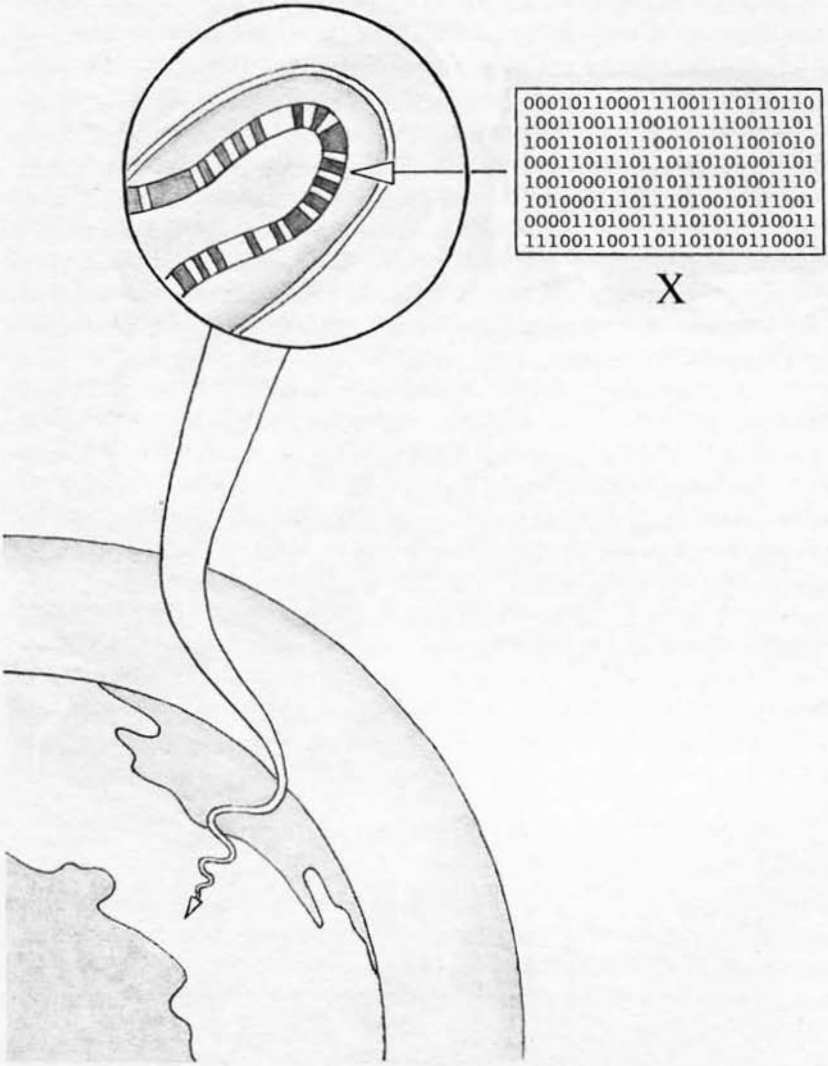

Figure 14. A biological structure coded by a binary sequence, X.

We shall give only a broad conceptual outline of these findings in this paper. (A detailed description is found in Monograph 2 of this series.) The essential idea is that simple laws lack the discriminating power to select highly complex forms from a welter of randomly distributed molecules. This can be expressed as follows in terms of the mathematical concept of information content:[64]

$$M(X) \leqslant 64^{60+L(M)-L(X)} \qquad (5)$$

Here, M(X) is the probability that the structure, X, will evolve somewhere on the earth in a 4.5-billion-year period (the estimated age of the earth according to current scientific opinion). L(M) represents the information contained in the physical system itself. This includes the information contained in the fundamental natural laws, plus any information built into the initial state of the system, or entering it from outside. L(X) represents the information content of the structure, X, which is being considered as a candidate for evolution.

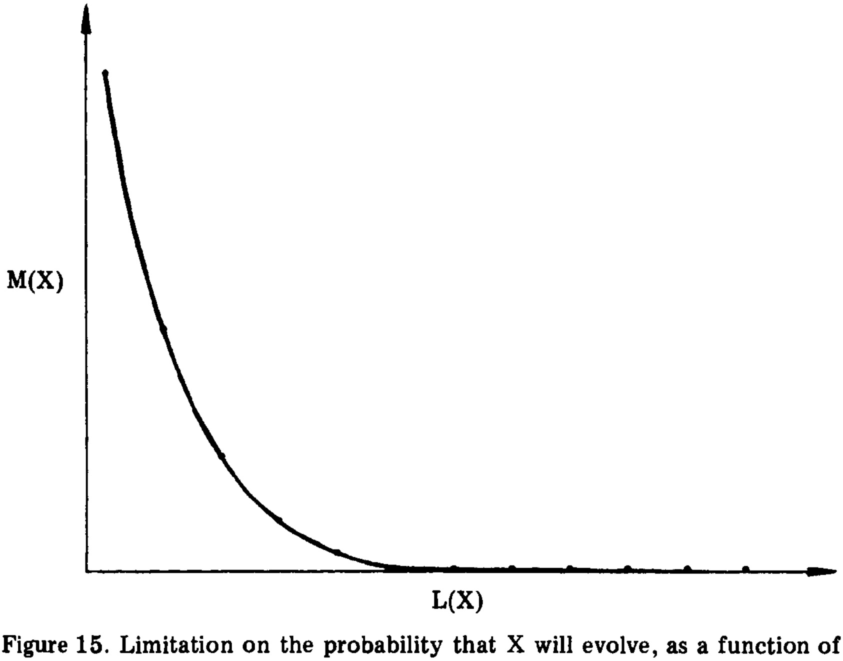

Figure 15. Limitation on the probability that X will evolve, as a function of its information content.

Earlier we considered the probability of forming a structure purely by chance, and saw that this probability went down exponentially (a^{-N}) with the number of variable elements (N) in the structure. Here the situation is similar, even though we are considering the simultaneous action of both random events and natural laws. The analysis in terms of information content indicates that all the information in X not supplied by the system must be provided by pure chance. Consequently, as the difference between L(X) and L(M) goes up, the probability of the evolution of X goes down exponentially.

Monograph 2 explains the concept of information content and argues that the elaborate structures of living organisms must embody large amounts of specific information. It follows that this information must come from somewhere. If the natural laws are very simple (as is true of the present laws of physics), then the information must come either from outside the system or from "chance." If it comes from chance, then the probability of evolution is circumscribed by bounds with large negative exponents (such as $64^{-80,000}$, as computed in Monograph 2). This means that evolution of complex life forms could not be expected to occur due to the action of chance and simple laws even in many billions of repetitions of the entire history of the earth.

The *E. coli* bacterium provides a practical example that may give some idea of why simple laws cannot be expected to generate the forms of living organisms. An *E. coli* cell possesses a number of spiral flagella. Each flagellum is connected by a kind of universal joint to a motor built into the outer wall of the cell.[65] When all the flagella are rotated in one direction by these motors, they act like the propellers of a submarine and drive the bacterium steadily through the water. The motors possess drive shafts and some kind of rotating discs, but the principle underlying their operation is still unknown.

Our question is: How did these motors originate? If we start with a cell that completely lacks such structures, then by what process could they arise? Surely the probability that one random mutation could produce the design for a complete functioning motor is exceedingly low, since many precisely structured components would have to be brought into existence at one time. On the other hand, if many successive mutations are required, then the standard theory of natural selection requires that each intermediate step be useful for the organism. But what useful

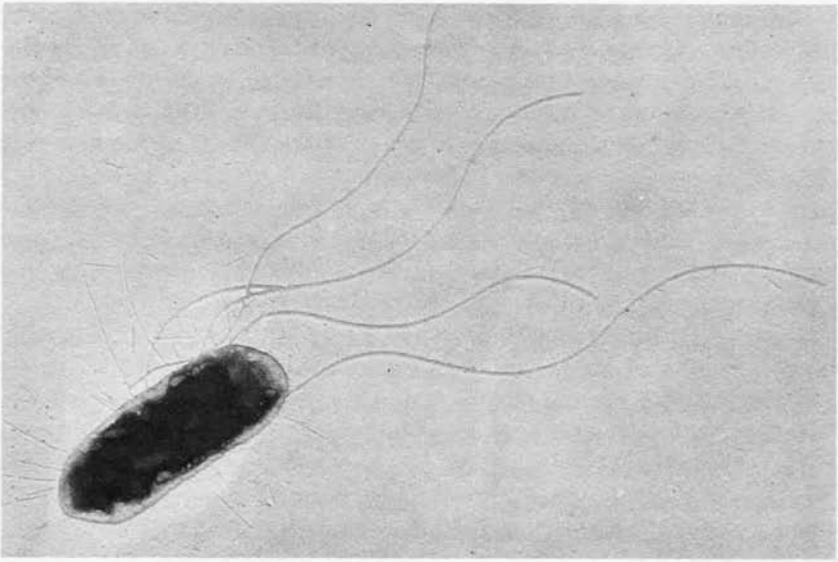

Figure 16. ***Escherichia coli*** **bacterium.**

intermediate steps are there between a motor and no motor? Can there exist a useful structure which is half a motor?

The process of natural selection is the only means envisioned thus far by which simple laws might yield complex organization. Yet if there does not exist a natural sequence of useful intermediate forms leading to a structure, this process cannot operate. Only pure chance is available to bridge the gaps, and this renders evolution fantastically unlikely, even over vast spans of time. Actually, there are innumerable instances of structures for which useful intermediate forms are hard to imagine. Also, the absence of the remains of intermediate forms in the fossil record has been one of the most striking findings of paleontology. This should give us some insight into why we should expect a limitation on evolution such as that expressed by inequality (5). (The mathematical derivation of (5) proceeds along somewhat different lines, however.)

This inequality implies that the information required to specify the structures of living organisms either must be built into the initial and boundary conditions of the system or must be built into the system's fundamental laws. To say that the necessary information was present in the initial state of the system certainly contradicts the idea of the disorganized primordial broth, or the earlier pre-solar gaseous nebula. It begs the question of origins by pushing it back to an earlier time, thus requiring some explanation for the origin of the complex initial conditions. The same can be said for the idea that the information was transmitted across the boundary of the system from outside in some form of code.

We, therefore, suggest that a more fruitful approach to the question of origins should begin with the understanding that the fundamental laws of nature are not as simple as modern scientists have supposed. It is to be expected that there are many additional laws specifically involved with life. It is interesting that in pondering the dilemmas of the quantum theory, the physicist E. Wigner was led to similar considerations. He proposed that

> The present laws of physics are at least incomplete without a translation into terms of mental phenomena. More likely they are inaccurate, the inaccuracy increasing with the increase of the role which life plays in the phenomena considered.[66]

A New Scientific Paradigm: Laws Beyond the Laws of Nature

We have seen that life possesses qualities beyond the limits of our physical descriptions, in spite of all the claims of its origin from inanimate molecules. Another fundamental quality of life is consciousness. To our knowledge, molecular evolutionists have never seriously tried to explain consciousness, because the symptoms of conscious awareness are simply beyond the realm of molecular description. Here we encounter a strong drawback in the chemical model of life.

Out of frustration, some people intentionally try to neglect this. For example, Niels Bohr remarked: "An analysis of the very concept of explanation would naturally begin and end with a renunciation as to explaining our own conscious activity."[67] This again is intellectual dishonesty. Bohr tried to explain everything by the quantum theory. However, since he felt that consciousness could not be explained by this theory, he had no choice but to "renounce" it.

But consciousness exists nonetheless. As Wigner remarked, "thought processes as well as consciousness are the primary concepts, . . . our knowledge of the external world is the content of our consciousness, and . . . this consciousness therefore cannot be denied."[68] If we are to understand the mystery of consciousness, and the many other mysteries of life, it is clear that we cannot remain within the narrow confines of mechanical and molecular thinking. A broader perspective on reality is needed.

In this section we would therefore like to introduce an alternative view of the basic principles underlying nature. We have referred to these basic principles as the absolute truth, or the ultimate cause of all phenomena. Even though most scientific theories deal in practice only with relative descriptions of nature, the goal of science has always been to seek out the ultimate principles underlying reality. Yet certain far-reaching assumptions about these principles have provided the foundation for all modern scientific research. The dominant scientific view of the past two hundred years has been that these ultimate principles consist of a few basic natural laws which can be expressed by mathematical formulas. We have listed one current version of these laws in Figure 2.

As this view appears to be far too restrictive to account for the phenomena of life, we are going to propose a diametrically different view, which may provide a framework and an inspiration for further scientific research. This is essentially the view of the absolute truth as presented in the ancient Sanskrit text *Bhagavad-gītā.*[69] We would like to stress that this view is not being offered as a dogma or as a metaphysical explanatory device incapable of scientific test. Although many of its features may appear difficult to verify empirically, others have very direct implications concerning what we may expect to observe. This view should serve as a stimulating challenge to the truly sicentific spirit that wishes to go beyond the very restrictive framework imposed on our scientific understanding of nature for the past two hundred years.

In both of these viewpoints the absolute truth may be described as the ultimate cause, or causes, lying behind all the phenomena of nature. Figure 17 contrasts the two views.

The first three points indicate features that both views of the absolute truth hold in common. The first point is that the ultimate laws must exist in a fashion not fully comprehensible to the

Basic Features	The View of Modern Science: The Laws of Nature	The Alternative View: *Paramātmā*
1. The absolute truth exists, but it is not fully conceivable to the human mind.	Yes	Yes
2. It exists invariantly throughout space.	Yes	Yes
3. It does not change with time.	Yes	Yes
4. It controls all manifestations.	Yes*	Yes
5. It exists as a unified whole.	No	Yes
6. It possesses the attribute of consciousness.	No	Yes
7. It corresponds with fixed mathematical expressions.	Yes	No
8. Amount of inherent variety, or information content.	Small	Unlimited

*The natural laws of science must be supplemented by initial and boundary conditions in order to completely determine the course of events.

Figure 17. Two alternative views of the absolute truth.

human mind. This is illustrated, for example, by the law of gravity. We cannot imagine how a force can act across empty space to pull one object towards another, and yet the law of gravity postulates that such a "force" exists. For this reason, the law of gravity, when first proposed by Newton, was rejected as "occultism" by Leibnitz and other European philosophers. We can see, however, that a law must have some unexplainable features if it is actually fundamental: if the law can be explained in terms of other laws, it cannot, by definition, be fundamental.

Points two and three are also characteristic of both views, and these also represent inconceivable features. In science, a natural law is taken by definition to be invariant with respect to both space and time. If it were not invariant, then one could inquire by what law it varies, and that law would be taken instead as the fundamental law.

Point four should ideally be "yes" in both columns. We should expect the ultimate cause to determine all phenomena completely. The natural laws of modern science, however, must be supplemented by initial conditions describing the state of affairs in nature at some arbitrary point in time. This is a rather unsatisfactory feature of the modern scientific view, and theories such as the Darwinian theory of evolution and the "big bang" theory of cosmology may be viewed as attempts to circumvent it.

For example, if we were forced to account for the existence of life forms by postulating initial conditions in which life forms already existed, then we could hardly say that our natural laws had explained life. The theory of evolution avoids this by positing a natural mechanism whereby life forms could arise from a chaotic cloud of gas or a "primordial soup." In this way the required initial condition is rendered as simple as possible, and all significant phenomena are attributed to the operation of the laws themselves. As we have already pointed out, however, this theory cannot be expected to hold true: it is absurd to suppose that simple pushes and pulls alone could organize a chaotic, seething mass of atomic particles into a system of life forms capable of exhibiting so many remarkable qualities and activities.

Another feature of the modern scientific view is chance, which enters the theory of quantum mechanics as a kind of repeated initial condition in the so-called "reduction of the wave packet." The role of chance in modern physics has many highly unsatisfactory features that we shall not enter into here. The basic point is that chance enters modern physical theory as an arbitrary yet unavoidable correction factor that modifies the behavior of the system under the natural laws. It is thus another aspect in which the natural laws fail to completely specify the phenomena of nature.

These drawbacks of the modern scientific view suggest the existence of natural laws of a higher order. Such laws would serve to provide the missing information needed to account for the origin of life, and would also serve to fill in the missing causal determination represented by "chance" in modern physics. By "higher order" we shall refer to one of the following set of progressively stronger properties:

(1) The laws cannot be reduced to the known laws of physics and chemistry.
(2) They can be expressed mathematically only by very elaborate formulas.
(3) They cannot be expressed mathematically at all, and relate to entities not amenable to numerical description.

The problems of evolutionary theory and quantum mechanics at least call for the existence of high-order laws of types (1) and (2). The simple push-pull laws of modern physics and chemistry are certainly inadequate to account for the phenomena of life, and the dilemmas of quantum theory suggest that they are not even adequate to account for the phenomena studied in physics. The very elaborate structures and activities manifested by living beings are particularly indicative of laws of type (2).

The phenomenon of consciousness, however, indicates that even laws of type (2) will not suffice to give a complete description of reality. Consciousness exists, and there is every reason to believe that it is qualitatively irreducible to mathematical description of any kind. An array of numbers, no matter how elaborate, can tell us nothing about a person's conscious awareness, even though it might describe the person's external bodily movements and electrochemical reactions with great accuracy. Therefore, if we are to entertain the idea of a complete description of reality, we must consider laws of type (3).

Our alternative view is based on the idea that the fundamental laws of nature must account for all phenomena, and that a cause must be at least as great as its effect in terms of information content. Thus we propose that an unlimited reservoir of fundamental laws lies behind nature, and that they determine all the features of nature, including living organisms. The existence of such higher laws and principles clearly provides unlimited possibilities for future scientific investigation, investigation which should prove to be much more fruitful than the many past invocations of the marvelous powers of "natural selection" and "chance."

Points 5, 6, and 7 also go together since for these points the two views are opposed. One of the basic ideals of modern science has been to find unity in nature. Since the absolute truth has been viewed as a system of mathematical laws, this ideal has been expressed by the requirement that the basic equations have the greatest possible mathematical simplicity. Einstein was one of the strongest proponents of this goal, and it is epitomized by his search for a "unified field theory" which would derive all the laws of physics from one basic mathematical rule.

However, this unity has not been attained. The basic laws are simply a list of apparently unrelated formulas and expressions, and further disunity is provided by the initial conditions (as well as by the arbitrary entrance of "chance" into quantum mechanics). The existence of many irreducible higher-order laws would seem to suggest that the absolute truth has an even greater disunity and is analogous to a gigantic cosmic laundry list.

In our alternative view, however, this unity is provided by a higher principle extending beyond the realm of laws that are capable of mathematical formulation. This is the principle of consciousness. As we have indicated, consciousness has eluded scientific explanation, and we propose that it cannot, even in principle, be reduced to a mathematical formulation.

We should stress here that the postulate that nature is mathematically describable in all essential features is also a drastic and highly restrictive a priori assumption. Why should we expect that reality can be encompassed by the patterns of finite symbol manipulation that we can invent and contemplate with our limited minds? It is perfectly possible for an entity to exist that cannot be described by equations, even though it may exhibit many features that can be so described.

In our alternative view, consciousness is taken as a fundamental feature of the absolute truth, and all the basic laws and principles of nature are seen to be integrated into a harmonious whole within the awareness of absolute consciousness. This means that the absolute truth exists as one unified, sentient being. Such a statement may appear to lie outside the realm of experimental observation. We introduce it both for the sake of philosophical completeness and for its implication that we should expect to find higher-order laws of nature that are of a psychological character. Such laws make sense in the context of the absolute truth as a primordial conscious being, but they do not fit sensibly into the mathematical framework of modern science. There the presence of such laws makes the world appear like a puppet show, with an elaborate script but neither an audience nor an author.

Point 8 is quite significant. The modern scientific view tries to depict nature in terms of a reduction to simple entities: atoms, molecules, and so on. This implies that the absolute truth is severely limited. This arbitrary a priori constraint on the nature of the absolute truth is one of the primary reasons why modern science cannot explain life.

We shall see some direct implications of this thesis once we have considered the fundamental nature of individual living beings. This is outlined in Figure 18.

Matter	Life
1. The inferior energy of the absolute truth.	1. The superior energy of the absolute truth.
2. Satisfies conservation of energy.	2. Satisfies conservation of energy.
3. Eternal.	3. Eternal.
4. Obeys the laws of physics and chemistry to some extent.	4. Non-physical and non-chemical.
5. Lacks consciousness and inherent meaning and purpose.	5. Possesses consciousness and inherent meaning and purpose.

Figure 18. The distinction between life and matter.

First of all, in the alternative view we are describing, matter and life are understood to be two distinct kinds of energy. Life is designated as the superior energy because it possesses the fundamental feature of consciousness, whereas matter does not. Both of these energies are eternal, and both are composed of basic elemental units. Both satisfy principles of conservation similar to those which are familiar from modern physics.

Matter is essentially an insentient substrate from which temporary forms can be constructed by atomic combinations. It derives its properties from the absolute truth, and its transformations are governed by laws emanating from this source. However, it is qualitatively inferior to its source of emanation, since it lacks the inherent property of consciousness.

Life consists of innumerable fundamental units, which may be referred to as *ātmās*, or living entities. These are described in Figure 19. The *ātmā* may be thought of as a fundamental quantized part of the absolute living being possessing the irreducible property of consciousness. The *ātmā* may thus be compared to the electron, which is regarded as the fundamental quantum of electricity. These quanta of life share the qualities of their absolute source—including consciousness and purposefulness—in minute degree, and are thus regarded as the superior energy of the absolute truth.

The *ātmā:*

1. Is the quantum of life.
2. Exists in unlimited numbers.
3. Cannot be created or destroyed (conservation principle).
4. Possesses the property of consciousness and free will.

Figure 19. Properties of the *ātmā*.

Both life and matter operate according to the same natural laws, or ultimate causative principles. However, certain laws are more specifically associated with life, and others are more specifically associated with matter. The simple push-pull laws of physics and chemistry undoubtably have some bearing on the behavior of matter, especially in circumstances where life is not significantly involved (inanimate matter). However, these are at best limiting cases of more general laws which are involved with life.

The interaction of life with matter ultimately depends upon higher-order principles that cannot be reduced to mathematical formulation. Essentially, the conscious, superior energy interacts with the inferior energy through the consciousness of the absolute truth. This interaction cannot be completely described in quantitative terms, but it can be understood and investigated. It entails fundamental psychological principles such as free will, purpose, and value. Ultimately, this interaction can be understood as the direction and supervision of the individual *ātmās* by the *paramātmā*: as the individual *ātmās* develop various desires and psychological states in the course of their experiences, the *paramātmā* observes these and adjusts the material situation accordingly.

Thus, the distinction between matter and life is the quality of consciousness. This is the main reason why scientists have had such difficulty in defining life. They either try to avoid consciousness completely, or they try to imagine generating it by molecular combination of inanimate matter.

Matter Under the Influence of Life

The actual subject of study in modern biology is thus not life itself, but the material structures that are associated with life and that develop according to the laws governing the interaction of life and matter. In Figure 20 we have outlined some specific indications of the influence of life on matter in familiar living organisms. The distinction between the two categories is, of course, a relative one, for the qualities of the materially conditioned living entities can be expressed through material arrangements to varying degrees.

First of all, matter by itself does not tend to exhibit very much specific information content. It is either found in simple organized forms like the diamond crystal, or it lacks organization altogether. On the other hand, the structures of living organisms exhibit an intricate organization which we are just beginning to understand. Consider the many complex systems involved in the human eye alone, for example. As we have already pointed out, this complexity strongly suggests that higher-order laws are involved.

Secondly, matter by itself tends to reduce to thermodynamically stable forms that usually consist of small molecules exhibit-

Matter by itself	Matter in the presence of life
1. Characterized by either low information content or absence of specific form.	1. Characterized by high information content and very specific form.
2. Reduces to thermodynamically stable states.	2. Thermodynamically unstable states play a dominant role.
3. No highly organized flow of matter.	3. Exhibits a precisely regulated flow of matter.
4. Tends to lose form or pattern under transformation.	4. Undergoes transformation without loss of complex pattern (reproduction).
5. Grows by external accumulation only.	5. Grows from within by an intricate construction process.
6. Exhibits only passive resistance.	6. Adaptive: tries to actively overcome obstacles.

Figure 20. The influence of life on matter.

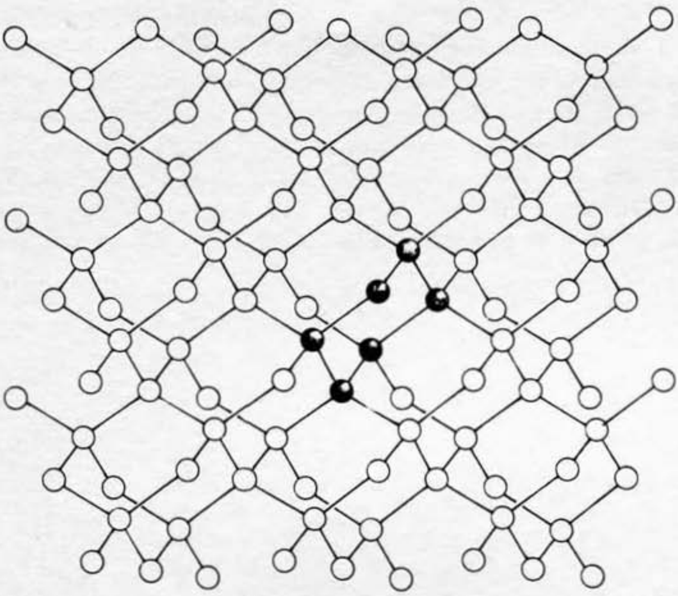

Figure 21. Diamond crystal lattice.

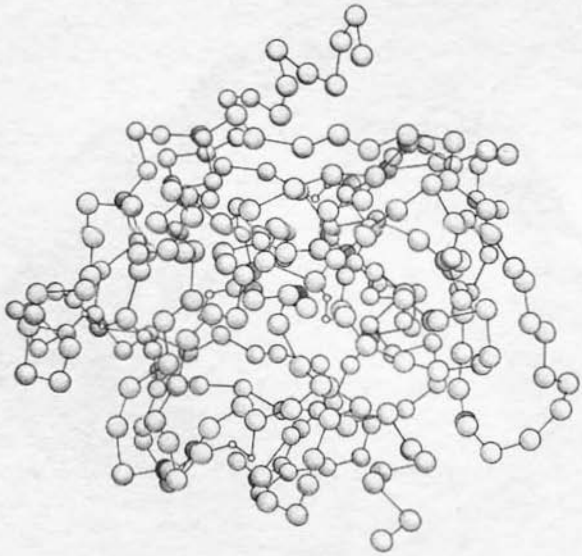

Figure 22. The chymotrypsin molecule.

ing little activity. On the other hand, in living organisms we see highly unstable molecules, such as the molecule of chymotrypsin illustrated in Figure 22. Such molecules are very readily broken down or denatured when subjected to ordinary chemical reactions.

Matter by itself tends to exhibit very simple patterns of flow, as we see for example in the flow of a river to the sea. Within living organisms, however, we see the kind of highly regulated chemical processes shown in Figure 23. This figure illustrates a

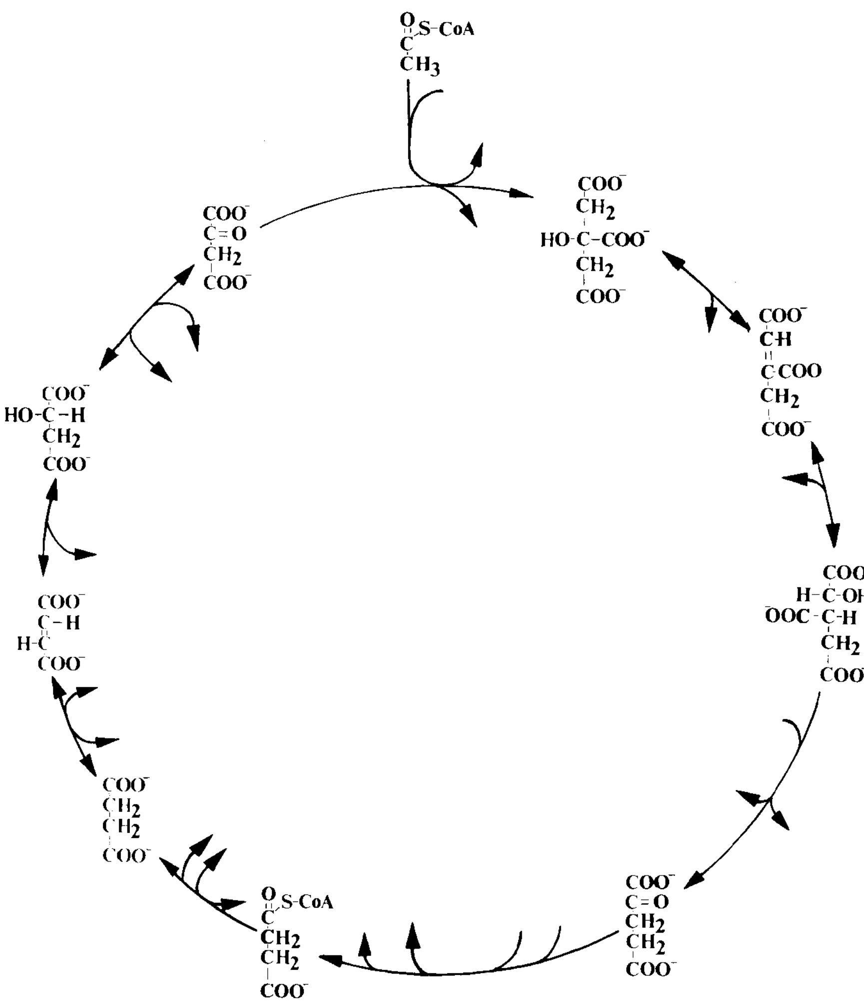

Figure 23. The flow of matter in human metabolism.

sequence of cellular chemical reactions known as the Kreb's cycle. Each reaction is controlled by a specific enzyme, and is adjusted so that the precise amount of the product needed by the cell is produced. The entire metabolism of even the simplest bacterial cells must contain thousands of precisely coordinated reactions of this kind. Thus, even if the cell is simply a chemical automation, it must have built into it logical instructions of complexity and sophistication that far surpass any computer program yet written by a human being. We propose that the higher order interactions ultimately stemming from the *paramātmā* play a role in the functioning of a cell analogous to the role of the programmer in a man-made computer. (In this connection we should note that computer programs are notorious for the amount of "debugging" work required to get them to work properly and to continue working in novel circumstances.)

Reproduction is another feature of living organisms that distinguishes them from inanimate matter. When inanimate matter is transformed, it tends to lose whatever structure or organization it may once have had. Consider, for example, the gradual decay of an abandoned car. In contrast, living organisms everywhere exhibit the renewal of their kind without apparent loss in vitality. We may also note that there are differences in the patterns of growth exhibited by inanimate matter and matter under the influence of life. In the former, growth proceeds by simple accumulation, as

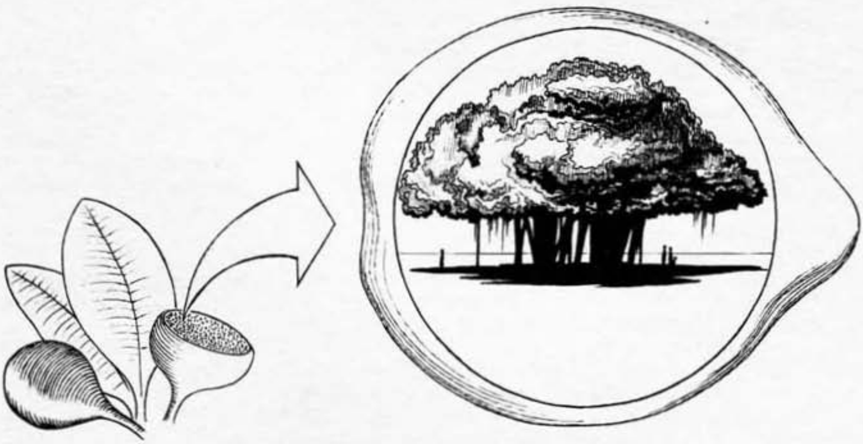

Figure 24. The process of perpetual renewal of living organisms.

we can see in the growth of a crystal. In a living organism, however, growth occurs by an elaborate internal construction process. At present, scientists have only dimly surmised the principles underlying such growth processes as the development of an embryo from a fertilized egg.

Finally, we can see that living organisms adapt and actively strive in many ways to overcome obstacles or achieve goals. This is exhibited in the process of healing, the migration of birds, the climbing of mountains, the building of industrial empires, and innumerable other examples. However, inanimate matter exhibits only passive resistance to change. Even man-made computers fail to display the kind of flexible adaptability visible in so-called primitive organisms. (In fact, computer systems tend to go out of control very easily, despite all attempts to build in safeguards, and for this reason they require constant human attention.)

Scientific Methods of Studying Matter and Life

We suspect that there are many fruitful avenues of scientific research that will lead to an understanding of some of the specific laws involved with life. We would particularly like to address the direct empirical investigation of the living entity, or *ātmā*, itself. The most significant implication of the new paradigm we have outlined is that it admits the possibility of the *ātmā's* recognizing its own existence, apart from matter. Figure 25 suggests how this investigation should be approached.

The basic idea here is that a material entity, such as an electron, is normally studied by taking advantage of its characteristic properties and laws of interaction. For example ESR spectroscopy takes advantage of the electron's magnetic interaction (or "spin" interaction) by the use of an oscillating magnetic field. If an entity does not interact in a particular way, then it is, of course, useless to try to observe it using that type of interaction. (For this reason the particle known as the neutrino is very hard to study—it does not interact very strongly with any of the standard measuring instruments employed by physicists.)

Similar considerations apply to the *ātmā*. According to the alternative view that we are presenting, the *ātmā* interacts with matter through the agency of the *paramātmā*, or the all-pervading conscious aspect of the absolute truth. This interaction depends

	MATTER	LIFE
Entity	Electron	*Ātmā*
Property	Charge	Consciousness
Laws of Interaction	Coulomb force law, Spin interaction	Psychological laws mediated through absolute consciousness
Means of Experimental Measurement	Set up an apparatus to take advantage of this law of interaction.	The same principle: we must also take advantage of the laws of interaction.
Example	Electron spin resonance spectroscopy	The techniques of *bhakti-yoga*

Figure 25. The study of life and matter contrasted.

on higher-order, non-mathematical laws relating to psychological principles such as desire and free will. For this reason we should not expect to be able to observe the *ātmā* by means of a standard physical apparatus, such as an electron microscope, which employs the familiar physical laws. However, since both the *ātmā* and the absolute truth, or *paramātmā*, are conscious, there is the possibility of direct conscious interaction between them. It is through this interaction that the *ātmā* can be directly studied, and this study also entails the study of the *paramātmā*.

Even though this subject matter is unknown in the domain of Western scientific knowledge, systematic and scientific procedures for the study of the *ātmā* have existed for a very long time. Centuries ago, they were expounded in the *Bhagavad-gītā* and other Sanskrit texts, and more recently they have been treated in great detail in such works as the *Bhakti-rasāmṛta-sindhu* of Śrīla Rūpa Goswāmī.[70] Here we will only give a brief outline of some basic principles underlying these procedures. In subsequent monographs in this series they will be described in detail.

Essentially, the object of study in this investigation is the investigator's personal self. The stringent experimental conditions necessary in ordinary physical experimentation must, therefore, be applied to the mind and senses, rather than to an external experimental apparatus. The sensory apparatus for the study of the *ātmā* resides in the *ātmā* itself. In the materially conditioned state the *ātmā* normally perceives external arrangements of matter through the gross senses of the physical body. The data for such perception pass through sense organs, nerves, and other physical structures. But in order for perception to take place, these data must ultimately reach the *ātmā*, or quantum of consciousness. The *ātmā* must therefore possess its own senses, or means of direct perception. It is this capacity of direct perception which must be invoked in order for the *ātmā* to study itself, other *ātmās*, and the *paramātmā*. Perception through the limiting medium of gross material instruments, including the bodily senses, can only give indirect evidence of the *ātmā*, since these instruments make use of an inferior mode of interaction.

One of the first steps required for the study of conscious interaction is therefore to purify the mind of the materially conditioned *ātmā*. A materially conditioned *ātmā*, or soul, is one who, devoid of real knowledge, assumes that he is a product of material interactions. He thinks that everything is within his power, and has a mental attitude characterized by the desire to lord it over nature. He tends to think that he can shape his own destiny, and that there is nothing beyond chance and matter. The words of the Nobel-prize-winning scientist Jacques Monod are indicative of this type of mentality:

> The ancient covenant is in pieces; man knows at last that he is alone in the universe's unfeeling immensity, out of which he emerged by chance. His destiny is nowhere spelled out, nor is his duty.[71]

Unfortunately, this attitude makes progress in the direct study of life extremely difficult.

As we have pointed out, the study of life ultimately involves the interaction between the individual quantum of consciousness and absolute, or universal consciousness, *paramātmā*. For the minute conscious entity to approach the supreme conscious source of all entities, a reverence for life in all its forms is needed, as well as a desire to cooperate harmoniously with the absolute source from which all life emanates. The study of life thus requires that higher psychological laws must be taken into account, just as the study of gross matter requires an appreciation of the natural laws which predominate in each particular experimental situation.

Conclusion

In this monograph we have pointed out that the theory of molecular evolution is not scientifically valid. This inherently weak theory has arisen because its propounders have no clear understanding of life and matter. To them life is just a mechanical transformation of inanimate matter, and they cannot speak about life in any language except that of chemistry and physics. But we have indicated that this approach is incompatible with the observed facts. We have further shown how life and matter can be understood as two completely different categories. One is not reducible to the other, although the latter can be transformed into structures of different sizes, shapes, and colors by the influence of the former.

Since life is a non-physical and non-chemical entity, any attempt to understand life in terms of chemistry and physics cannot go very far. Honest and thoughtful scientists are beginning to realize this.

We have discussed an alternative scientific viewpoint. Both the modern scientific approach and the new paradigm agree that there is an absolute truth. However, the view of modern science reduces the absolute truth to nothing but some pushes and pulls of interacting atomic particles. This view is very unsatisfying and cannot meaningfully explain many observed phenomena pertaining to both life and matter. The new paradigm, however, reveals that the absolute truth is a supremely conscious being, identified as *paramātmā. Paramātmā* possesses unique features or qualities for generating both matter and life. As the leader of a nation is different from his functionary departments, although they are dependent upon him, so both life and matter emanate from that supremely conscious being, the original life, although they are different energies. This is quite reasonable, and it can explain all the features of both life and matter, as well as open up new possibilities of investigation precluded by the reductionistic view. We suggest that serious consideration of this new scientific paradigm will prove very fruitful. The famous scientist Louis Pasteur remarked:

> I have been looking for spontaneous generation for twenty years without discovering it. No, I do not judge it impossible. But what allows you to make it the origin of life? You place matter before

life and you decide that matter has existed for all eternity. How do you know that the incessant progress of science will not compell scientists ... to consider that life has existed during eternity, and not matter? You pass from matter to life because your intelligence of today ... cannot conceive things otherwise. How do you know that in ten thousand years one will not consider it more likely that matter has emerged from life?[72]

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$$\frac{\text{(volume of "soup")} \times \text{(microseconds in } 10^{12} \text{ years)}}{\text{(volume of } E.\ coli \text{ cell)}}$$

Formula (5) thus gives a bound on the probability that k specific molecules will be found together in some *E. coli* sized volume in the soup at some time in a 10^{12} year period. By taking faster rates for the molecular events one can obtain the same results for proportionately shorter time spans.
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Throughout his studies, he was struck by the lack of any meaningful foundation to reality in modern scientific theories. His dissatisfaction with this culminated in 1970, when he studied the reduction of man to a Turing machine, a kind of abstract clockwork. Surely, he felt, the truth must be something different from this. Consequently, he began to study many different philosophies, with a view to finding a practical route to higher knowledge. In 1972 he discovered some of the books of His Divine Grace A. C. Bhaktivedanta Swami Prabhupāda, and was struck by the beauty of their conceptions and the clarity of their presentation. Here was a deeply meaningful philosophy capable of practical application in day-to-day life. He became initiated as Śrīla Prabhupāda's disciple in 1975, and is now a member of Bhaktivedanta Institute.