EDITORIAL

DOES EVOLUTION QUALIFY AS A SCIENTIFIC PRINCIPLE?

WHAT THIS ARTICLE IS ABOUT

This editorial is a response to a statement signed by leading biologists affirming evolution as a principle of science. The statement, published recently in the Humanist, *asserts that evolution qualifies exceptionally well as a principle of science. A survey of the scientific literature indicates that this is not the case. Fundamental disagreements center around questions of whether or not evolution can be tested by the same criteria used for other scientific theories. Many feel that evolution should be treated differently than ordinary science. This would also exclude it from qualifying as a bona fide principle of science.*

The *Humanist*, an official publication of the American Humanist Association and the American Ethical Union, recently (Jan/Feb 1977) published a statement affirming evolution as a principle of science. The statement, signed by 163 scholars, most of whom are biologists in leading universities of the United States, was prepared for distribution to major public school districts in the United States. Among its sponsors are such notables as Isaac Asimov, Linus Pauling, and George Gaylord Simpson.

The statement points out that "all known forms of life including human beings developed by a lengthy process of evolution." This broad perspective on evolution is what Kerkut (1960, p 157) calls the "general theory of evolution," in contrast to the "special theory of evolution" which deals with small variations in organisms such as have been observed in nature and the laboratory. The statement in the *Humanist* also indicates that the principle of biological evolution meets "exceptionally well" the criteria demanded by science of being "*firmly established*...on rigorous evidence" and that in recent years more confirmation of the principle of natural selection and adaptation as proposed by Darwin and Wallace has continued to accumulate. The statement further asserts that "creationism is not scientific," while evolution is "strictly scientific."

On the other hand there has been an ongoing debate within the scientific community, largely among individuals who believe in evolution, about the validity of evolution as a scientific principle. The statement published in the *Humanist* suggests that under the pressure of current criticism leveled at evolution, basic scientific values may be overlooked or given secondary place over other factors.

Much of the debate regarding the validity of evolution revolves around the elementary notion that science explains things on the basis of cause

and effect. Simply stated, given certain conditions, certain results can be expected. This feature gives science its predictive qualities. For instance the statement "a magnet attracts iron" can be tested and used to predict what will happen when the two are near each other.

Hans Reichenbach in *The Rise of Scientific Philosophy* (1951, p 89) emphasizes the necessity of a predictive quality for science:

> *A mere report of relations observed in the past cannot be called knowledge; if knowledge is to reveal objective relations of physical objects, it must include reliable predictions. A radical empiricism, therefore, denies the possibility of knowledge.*

The concept of predictability and subsequent testability has prompted the noted scientific philosopher Karl Popper to further emphasize that if an explanation cannot be adequately tested, it is not scientific. The concept must be testable (i.e., falsifiable) to qualify. Any kind of explanation will not do; it must be amenable to a testing process. If it survives testing, it can qualify. In our magnet example, we might propose that objects of only a certain color (and not a magnet) attract iron. If a red magnet were found to work, we could further test the notion by using a wooden block of the same color as the magnet and thus disprove the color theory. Popper in his book *The Logic of Scientific Discovery* (1968, p 40) is emphatic on the matter of falsification. He states:

> *But I shall certainly admit a system as empirical or scientific only if it is capable of being* tested *by experience. These considerations suggest that not the* verifiability *but the* falsifiability *of a system to be taken as a criterion of demarcation.*

The idea that a genuine scientific idea must have the consistency that gives it predictive value, and the potential for falsification, has received a great deal of attention during the past few years among scientific philosophers and evolutionists. There is very little disagreement with this aspect of science as enunciated by Popper, and there is genuine concern as to how to apply this principle to the theory of evolution. The unrepeatable or untestable events postulated for evolution are not amenable to evaluation on the basis of consistency and prediction. Thus the concept of evolution as a principle of science is being questioned at a most fundamental level. Does it really qualify as a scientific principle? Some examples of deficiencies follow.

The concept of natural selection by survival of the fittest is the basic evolutionary mechanism. This concept does not qualify as a scientific principle, since fitness is equivalent to survival. Here we have a case of circular reasoning; no consistency or predictive value can be tested. According to this idea, organisms have survived through the evolutionary process because they are better fit, and the way one tells they are better fit is that they survive. A number of evolutionary scholars have labeled the principle of survival of the fittest a tautology (e.g., Waddington 1957,

Eden 1967, Peters 1976). Popper (1963) attacks the unfalsifiable nature of the concept and concludes:

> *If, more especially, we accept that statistical definition of fitness which defines fitness by actual survival, then the survival of the fittest becomes tautological, and irrefutable.*

The concept of survival of the fittest of itself does not necessarily imply any evolution. Would not the fittest survive, whether they evolved or were created? The noted evolutionist Mayr (1976, p3) speaks of "an all-powerful natural selection." Platnick (1977) wonders if there is any difference in this kind of explanation as compared to that of an all-powerful Creator.

Some evolutionary biologists are of the opinion that it is not necessarily the fittest that survive through the evolutionary process, but those that are best adapted to the requirements of evolution. Others have emphasized that survival of the organism is not as important as its fecundity. In both cases the problem of predictability remains. In a symposium volume celebrating 100 years of Darwinism the prominent geneticist Waddington (1960, p 385) evaluates the matter of fecundity. He states:

> *Natural selection, which was at first considered as though it were a hypothesis that was in need of experimental or observational confirmation, turns out on closer inspection to be a tautology, a statement of inevitable although previously unrecognized relation. It states that the fittest individuals in a population (defined as those which leave most offspring) will leave most offspring.*

Another problem associated with the untestability of evolutionary theory is that the theory explains too much. Grene (1959) points out that "whatever might at first sight appear as evidence against the theory is assimilated by redefinition into the theory." Evolutionary theory is broad enough to accommodate almost any data that may be applied. Two ecologists Birch & Ehrlich (1967) emphasize this. They state:

> *Our theory of evolution has become, as Popper described, one which cannot be refuted by any possible observations. Every conceivable observation can be fitted into it. It is thus 'outside of empirical science' but not necessarily false. No one can think of ways in which to test it.*

No matter what is observed, there usually is an appropriate evolutionary explanation for it. If an organ or organism develops, it has positive survival value; if it degenerates, it has negative survival value. If a complex biological system appears suddenly, it is due to preadaptation. "Living fossils" (contemporary representatives of organisms expected to be extinct) survive because the environment did not change. If the environment changes and an evolutionary lineage survives, it is due to adaptation. If the lineage dies, it is because the environment changed too much, etc. Hence the concept cannot be falsified. Platnick (1977) states that this type of

situation "makes of evolutionary biologists spinners of tales, bedtime story-tellers, instead of empirical investigators."

A few scientists (e.g., Williams 1970, 1973; Ball 1975, Ferguson 1976) have tried to show that evolutionary theory can predict. Their attempts, however, are concerned with the small changes of the special theory of evolution instead of the general one which is at issue and which is the main subject of the declaration published in the *Humanist*. These small changes do not prove large ones as Grene (1959) points out:

> *By what right are we to extrapolate the pattern by which colour or other such superficial characters are governed to the origin of species, let alone of classes, orders, phyla of living organisms?*

The question of the testability of the general theory of evolution remains.

Basic textbooks of biology usually illustrate evolution using the concept of homologous structures. Here we have another example of circular reasoning that would not pass the prediction test for science. Homologous structures are defined as comparable parts of different life forms that have a common evolutionary origin. The forelimbs of a salamander, crocodile, bird, bat, whale, mole and man all have the same basic bone structure and are considered homologous. Similarity does not necessarily imply evolution. A student commenting to an evolutionary professor put it aptly: "They find a muscle in an animal and give it a name; in another animal they find a muscle in a similar position and give it the same name and then call it evolution." Darwin himself used the argument of similarity of structure to support evolution.

Lee (1969) points out that the argument is logically invalid:

> *He* [Darwin] *argued that morphological similarities were due to common descent and yet offered no further really acceptable evidence for common descent save morphological similarities. A circular piece of reasoning if there ever was one.*

Hull (1967) makes the same complaint:

> *It is tautological to say that homologous resemblances are indicative of common line of descent, since by definition homologous resemblances are those resemblances due to common line of descent.*

The same difficulty reappears when evolutionists attempt to classify living and fossil organisms so that their evolutionary relationships are revealed. One might select, for example, the group of invertebrates which most closely resembles the chordates and place the two groups near each other in a classification scheme. The classification is then often used as evidence for an evolutionary relationship.

Several widely divergent schools of thought have developed regarding the kinds of characteristics that are most important in determining evolutionary relationships. As a result opinions as to whether Popper's criteria of falsifiability can be satisfied also differ widely (e.g., Bock 1973, Wiley

1975). Perhaps the soundest conclusion expressed by a number of scholars is that from a practical standpoint the process of evolution is too complex and past events too unknown to permit a meaningful reconstruction of evolutionary phylogenetic patterns (Manser 1965, Barker 1969, Lee 1969, Platnick 1977). Orians (1973) and Slobodkin (1968) admit it is very difficult. An alternative is to adopt the view expressed by the prominent evolutionist Ernst Mayr (1976, p. 411) that classification of organisms is an "art." This would remove the problem altogether from the arena of science.

This brings us to another point: a number of scientists and scientific philosophers in attempting to reconcile the lack of rigor in evolutionary theory compared to current scientific standards have proposed that evolution be treated differently. This, of course, tends to alienate it from science and from being a "principle of science" as proposed in the *Humanist* statement. Such views have been proposed by Beckner (1959), Scriven (1959), Smart (1963), and Manser (1965), while Barker (1969) and Flew (1966) propose that evolution is more closely related to historical studies than to typical science. Ruse (1973) on the other hand suggests that evolutionary events are subject to the same scientific principles that apply to most of science. Platnick (1977) in the journal *Systematic Zoology* is still more emphatic:

> *Evolutionary biologists have a choice to make: either we agree with Mayr that narrative explanations are the name of the game, and continue drifting away from the rest of biology into an area ruled only by authority and consensus, or we insist that whenever possible our explanations be testable and potentially falsifiable and that evolutionary biology rejoin the scientific community at large.*

The concept of creation does not appear to meet the criterion of falsifiability any better than evolution. Science is not at its best when dealing with unique past events, whether these be considered as evolution or creation. Therefore it is surprising to find a statement signed by more than 120 scientists stating that creationism is "a purely religious view" while evolution is labeled as "strictly scientific."

The controversy over whether or not evolution is a scientific principle has reached beyond the scientific community. In his article entitled "Darwin's Mistake," published in *Harper's Magazine*, Bethell (1976) states his belief that Darwin's theory "is on the verge of collapse." The jurist Macbeth (1971) in his book *Darwin Retried* presents a long list of illogical arguments employed in support of evolution. He does not defend creation, yet states that "Darwinism itself has become a religion" (p 126).

The statement in the *Humanist* affirming evolution as a principle of science has the support of many influential scientists; yet a review of the literature of both science and the philosophy of science reveals significant doubt regarding its validity. In view of this, it is sobering to think that so many scientists should affirm, in a public statement to be sent to public schools, that evolution is a principle of science that meets "exceptionally

well" the criteria of science which are based on "rigorous evidence." Apparently this is not the case at all. Evolutionists need to re-examine their thinking and re-evaluate their claims.

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REACTIONS

Readers are invited to submit their reactions to the articles in our journal. Please address contributions to: ORIGINS, Geoscience Research Institute, 11060 Campus St., Loma Linda, California 92350 USA.

Re: Walton: The chemical composition of the earth's original atmosphere (ORIGINS 3:66-84).

One very important influence on the structure and evolution of the earth's atmosphere is the solar energy source. The fairly reliable results of stellar evolution theory suggest that in the past the sun's luminosity was considerably less than it is at the present. This could result in a very cold earth, below the freezing point of seawater, at a time when organic evolution theory would insist upon a thriving ecosphere. The difficulty is to explain how the temperature of the earth's surface and atmosphere could have been maintained near or even above the present value.

Carl Sagan & George Mullen (1972. Earth and Mars: evolution of atmospheres and surface temperatures. Science 177:52) consider this problem in some detail. They point out that a simple increase in carbon dioxide levels in the atmosphere, and hence an increase in the "greenhouse" effect, would not have been sufficient to compensate for the estimated 40% change in solar luminosity, the primary reason being that the strongest infrared absorption bands are almost saturated. Further, a number of other common oxides can be eliminated as possible candidates because they do not have the necessary absorption in the infrared. Their conclusion is that small amounts of ammonia in a reducing atmosphere would be quite adequate, since ammonia has an appreciable absorption at the necessary wavelengths.

Thus if the early atmosphere of the earth were oxidizing, as the evidence presented by Walton strongly suggests, one is left with the problem of explaining how the early earth was kept warm. Either some other mechanism must be proposed or else the basic assumptions must be modified.

To illustrate the sensitivity of the structure of the earth's atmosphere, consider the results of a paper presented by M.H. Hart at the January 1977 meeting of the American Astronomical Society in Honolulu in which he described a calculation of the habitable zone about the sun using a varying solar luminosity as well as an initial reducing atmosphere. The minimum distance for the earth to avoid a runaway greenhouse effect was 0.95 AU (astronomical unit equal to the mean radius of the earth's orbit) whereas the maximum distance to avoid runaway glaciation was only 1.01 AU.

It has been suggested that one possible mechanism is for the gravitational constant G to decrease slowly with time. This would mean that in the past it would have been greater leading to a smaller orbit for the earth as well as a

brighter sun. (See Fred Hoyle. 1975. Astronomy and cosmology: a modern course. San Francisco: W.H. Freeman and Co., p 540-545). However, this hypothesis has certain difficulties and is not well accepted.

Another contribution to the thermal equilibrium of the earth's surface is presented by D.L. Turcotte, J.L. Cisne, & J.C. Nordman (1977. On the evolution of the lunar orbit. Icarus 30:254). They have calculated that tidal heating in the past from the moon, when it would have been closer to the earth, could have significantly raised the temperature of the earth's surface. Actually, the problem is too much heat. At a separation of 10 earth radii (the present separation is about 60 earth radii) the energy dissipation from tidal friction would have been equal to the solar flux. The net result would have been a drastic increase in the surface temperature of the earth — several hundred degrees Celsius — which would not only melt any frozen oceans, but would also vaporize them!

It would seem that the simultaneous conditions of an increasing solar luminosity, an existing oxidizing atmosphere of Earth, and the tidal evolution of the moon's orbit put very tight constraints on any evolutionary calculation of the earth's atmosphere. For organic evolution to be possible the temperature of the earth's surface must be kept in the range for liquid water. Is this even possible?

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RE: Brand: Homologies (ORIGINS 3:109-111).

Dr. Brand has summarized the traditional creationist position concerning the meaning of biological homologies; namely, that essential similarities between groups of organisms reflect the master plan of an intelligent Designer. Certainly diversity among living organisms is one of the most obvious facts of nature. Beginning biology students are often overwhelmed by the tremendous variety of organisms and the classification schemes which attempt to bring order to an otherwise unmanageable and bewildering array of life forms. Classification schemes group organisms into categories based primarily upon structural similarities. The fact that structural similarities (not to exclude biochemical and other similarities) occur among organisms is recognized by all; the question of *why* these similarities exist is answered in a fundamentally different way by evolutionists and creationists. It is my purpose to analyze this question and to consider some of the ramifications of the creationist point of view. I will attempt to show why the evolutionary interpretation of homologies is the one held by most biologists.

We know that structural features of organisms have a genetic basis and that a given structure is subject to variation among offspring. Mutation, genetic

drift, and natural selection, among other factors, determine what structural features are produced and their subsequent destiny. So far as I am aware, creationists do not invoke supernatural intervention in any of these processes. These processes are known to be sufficiently efficacious to produce what biologists call new species. Species are characterized by structural and other differences of such a magnitude as to prevent interbreeding. There is therefore a natural, as opposed to a supernatural, explanation for structural similarities (homologies) and differences between newly produced species or between ancestral-descendant species.

Creationists respond to these facts by placing limits upon how much change can be accomplished by these natural processes. Similarities (homologies) *within* the taxa created by the Designer (the dog kind, for example) are accounted for by natural (genetic) processes; similarities *between* created taxa (dogs and cats) are accounted for not by common ancestry but by a common plan conceived by the Creator. Most creationists, for example, would recognize naturally derived homologies among the different breeds of dogs, and perhaps between dogs, foxes, and wolves depending upon the limits of the originally created taxon; structural similarities between the forelimbs of dogs, cats, bats, and man, on the other hand, are believed to be supernaturally derived, i.e., created according to a master plan.

For those creationists who believe that creation occurred relatively recently, the originally created taxa must be rather narrowly delimited. This is necessary because naturally derived taxa and consequent homologies ordinarily require much time. If the created taxa are conceived too broadly, the amount of natural variation leading to new taxa that must have occurred since creation within the restrictions of a short-earth chronology would have had to have proceeded at rates faster than can be accounted for on a genetic basis. In this paradoxical situation, the creationist believes in evolution more strongly than evolutionists!

Imagine an evolutionist and a creationist in a dispute over a given set of homologous structures between widely separated (distantly related) taxa. The evolutionist contends that the structural similarities before him are evidence that the organisms (taxa) involved have a common ancestry. He reasons from what he knows about evolutionary mechanisms and contends that they are sufficient to account for the disputed homologies. He believes he can account for observed differences and similarities on a natural basis and sees no compelling reasons why supernatural agencies need be invoked. The creationist cannot admit that the disputed similarities are due to natural causes and contends that the similarities reflect the fact that the taxa were designed and created according to a plan conceived by a master Designer. The creationist has certain advantages in this argument. He can attack the evolutionist at many points, questioning the possibility of this or that mutation, the efficacy of natural selection, that order cannot arise out of random events. The evolutionist is clearly on the defensive. His theories and assumptions are well known and readily available to the creationist who can pick and choose with what he does

and does not agree. The creationist position is difficult to attack because it has not been detailed in scientific journals and because it ultimately resides in the thought patterns of the Designer which are rather inaccessible to the non-believer. As long as this is so, the creationist position has the advantage (disadvantage?) of not being able to be proven false. It is similar to the argument that the earth was created in 4004 B.C. with all strata and contained fossils intact, trees with a number of "growth" rings, the first man with his navel; age and history are apparent — not real. There is no way to refute such a position and yet no one that I know seriously holds this view even though it is consistent with all possible evidence.

However, there are certain questions that one can legitimately ask of the creationist. A logical consequence of the creationist interpretation of homologies is that there should be a detectable difference between structural similarities produced by nature and those that have their origin in the mind of the Designer. If there is a difference, the creationist should be able to supply criteria to be utilized in distinguishing between natural and supernatural homologies and should be able to apply these criteria to living and fossil plants and animals. If there is no difference, the creationist interpretation appears to be an ad hoc argument designed to harmonize science and Scripture.

Again imagine a working paleontologist studying an array of fossil and living forms. Utilizing the criteria for distinguishing natural from supernatural homologies, he should be able to isolate all natural homologies and taxa from the array which would then facilitate recognition of the created groups. On the other hand, the paleontologist would be substantially aided in his understanding of the homologies and consequent classification of the forms before him if he knew something about the mind (thought patterns) of the Designer. This would give him some insight into the created groups and he would literally be "thinking the thoughts of the Creator after Him."

If the creationist paleontologist finds that he cannot distinguish between natural and supernatural homologies and natural and supernatural taxa, perhaps this suggests that he should examine his basic premises. Possible sources of error are:

1. his criteria for delimiting natural and supernatural homologies are faulty;
2. he has misunderstood the thought patterns of the Designer;
3. the evolutionary position is correct and variation among organisms cannot be divided into natural and created categories.

The master Designer view of homologies is not seriously entertained because it rests on an assumption not amenable to empirical analysis. So long as homologies can be explained without resorting to supernatural causes and in this way bring unity to a great mass of observations and accumulated information, the creationist view of homologies, even though consistent with its premises and technically not subject to falsification, will simply be ignored.

The analogy drawn between wheeled vehicles and organisms deserves comment. Certainly the author is correct in concluding that no one would conclude that cars evolved (in a biological sense) from two-wheeled carts even though one can arrange them in a series from primitive to complex based upon similarity of parts. The stated reason that they can be so arranged is that they were all designed to operate under the same natural laws. Diversity of types reflects the designers' efforts to satisfy different functional requirements by modifying basic parts or bringing them together in new ways resulting in different structural types. Unlike vehicles, however, organisms reproduce *themselves* and because of the genetic mechanism involved, offspring may differ from parents. These differences may lead to descendant types that are structurally different from their ancestors, but the ancestral-descendant relationship remains detectable by analysis of modified (homologous) parts. These processes are controlled by genetic and environmental factors and can be explained without recourse to a Designer. Therefore the contention that the same principles of comparison are applicable to vehicles and organisms is like comparing apples with bolts; apples can produce more apples — more bolts can be produced only by man. Only if one has evidence that man can produce apples is the logic satisfied.

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ARTICLES

ORGANIZATION AND THE ORIGIN OF LIFE

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WHAT THIS ARTICLE IS ABOUT

Dr. Walton points out two major problems associated with the spontaneous origin of life that are not answered by physical theory. First is the matter of producing, on the basis of random activity, highly organized molecules essential to life. Secondly is the problem of developing a self-replicating "living" system that would not degenerate as a result of random molecular activity. In the context of the problems posed, the author then proceeds to evaluate: 1) modern concepts of natural selection, 2) non-equilibrium thermodynamics, 3) the assumption that there is something unique to biological systems, and 4) the concept of a Designer associated with the origin of life. The author feels that the concept of creation permits reconciliation of the data of physics and biology.

MOLECULAR BIOLOGY AND THE FUNDAMENTAL LAWS OF PHYSICS AND CHEMISTRY

Molecular biologists have made remarkable progress in the last few decades towards an understanding of the mechanisms of cell reproduction and metabolism. For example, the Watson-Crick model provides deep insight into the heredity function of DNA and its mechanism of replication. The essential steps of the *in vivo* chain of events in protein synthesis are also understood at least in outline.

These achievements have encouraged some molecular biologists in the belief that the "secret of life" has been unveiled and that the problem of the origin and continuance of living structures is basically solved. It is frequently asserted in popular texts that cell biology can now be understood entirely in terms of the conventional laws of physics and chemistry,[1] or that "no paradoxes had turned up" in the reduction of biology to physics.[2] Crick is one of the most vigorous champions of this view, making the point this way:

> *... as we learn more about biological organisms, even the simplest ones, it becomes even more inconceivable that they could have just assembled themselves by a random process. So that this really is the major problem of biology. How did this complexity arise?*
>
> *The great news is that we know the answer to this question, at least in outline.*[3]

This position has not gone unchallenged. A considerable number of scientists, particularly from the area of theoretical physics and chemistry,

have voiced doubt or positive disagreement with the *kerygma* of Crick. Some of the most eminent and influential theoreticians such as Schrödinger, Wigner, Polanyi and Longuet-Higgins have suggested that we cannot understand the origin and stability of biological structures in terms of the presently known laws of physics. Something of a confrontation has developed between physicists and biologists over this whole question.

Living matter is distinguished from inanimate matter by its organization, function, purpose, adaptability etc., but these concepts are foreign in the physical sciences. These theoreticians suggest that we do not understand at present how to account for some of them, or even how to express them in the language of theoretical physics.[4] One of the clearest thinkers in this area is Pattee, who has outlined the difficulties in objective fashion in a series of papers.[5] It is the concern of physics to find out whether the facts of a given phenomenon can be predicted or reduced to a fundamental theory. Considerable success has been achieved in understanding the structure and organization of stellar systems in terms of gravitational forces, non-living matter in terms of electromagnetic forces, and atomic nuclei in terms of nuclear forces. The fundamental theory which unifies and interrelates all these phenomena is provided by relativistic quantum mechanics. The special structures and organization of living cells do not seem to fit within this framework, and as yet no force or combination of interactions has been recognised which could be responsible for producing their special organization.[5]

The fact that some or all cell functions can be duplicated in the test tube using parts isolated from the organism does not solve the problem. It is not doubted that the atoms and molecules making up the cell individually obey the laws of physics and chemistry. The problem lies in the origin and continuance of the highly unlikely organization of these atoms and molecules. The electronic computer provides a striking analogy to the living cell. Nobody doubts that the parts of the computer all obey the laws of mechanics and electronics. Sections of the computer can be detached from the whole and made to perform their function in a "mock up," analogous to the test tube experiments with cell components. The secret of the computer, the key to its performance, lies in the design and highly unlikely organization of the parts which harness the laws of electronics and mechanics. In the computer, of course, this organization was specially arranged by the designers and builders, and the computer continues to operate because of the attentions of service engineers. The problem that molecular biologists and theoretical physicists are addressing is how organization of an even higher order could have arisen spontaneously in living systems and continue to function and develop.

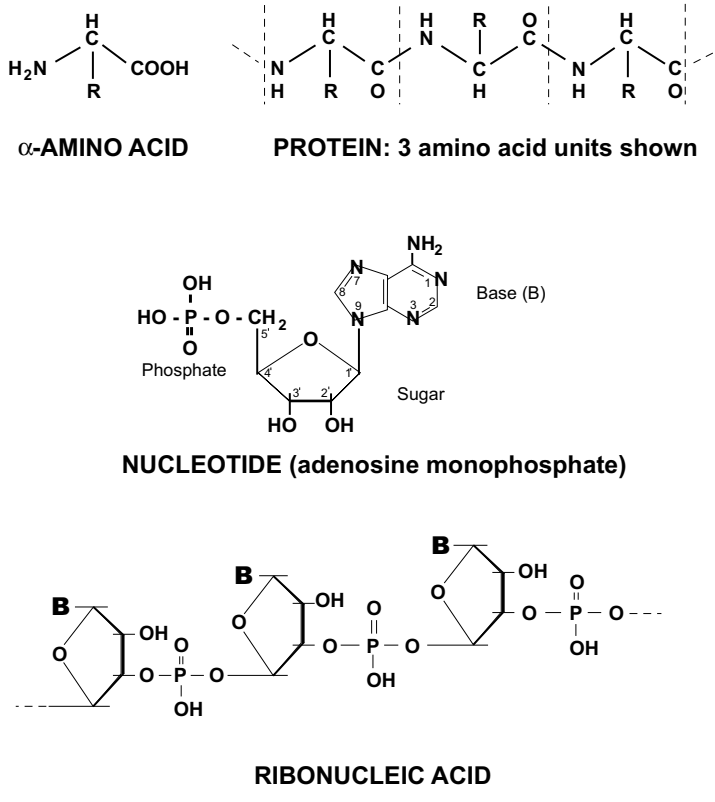

FIGURE 1. Structures of bio-monomers and -polymers.

The purpose of this article is to present some of the questions about living matter which theoretical physicists feel cannot be answered by physical theory as it stands now. Two major problems will be considered: the spontaneous origin of self-replicating systems, and secondly, the stability and reliability of reproductive and metabolic functions. Finally, various solutions to these problems proposed by contemporary scientists will be examined.

RANDOM COMBINATION OF BIOMONOMERS AND THE ORIGIN OF A SELF-REPLICATING SYSTEM

The replication mechanism of simple organisms of the present day depends on the cooperation of at least two types of large biopolymers, the proteins (or enzymes) and the nucleic acids. Both these types of macro-

molecules are made up of linear sequences of biomonomers, the amino acids and nucleotides respectively. Their primary structures and components are shown schematically in Figure 1. Twenty main types of α-amino acids are found in proteins from living matter, which differ from each other in the nature of the group R attached to the central α-carbon atom. A living cell contains several thousand different proteins which are typically a hundred or so amino acid units long. Nucleic acids are made from four different nucleotides which are distinguished by the nature of the heterocyclic base B attached to the sugar molecule; they range from about one hundred to scores of thousands of nucleotides in length.

These macromolecules perform highly specific tasks in the replication and metabolism of the organism. It is the exact linear sequence of the amino acids or nucleotides which fits the macromolecule for its particular function. In DNA, for example, the sequence of nucleotides carries the genetic information which is translated into the fabric and organization of the cell. If the sequence is disarranged, then the genetic information is lost, i.e., becomes meaningless on translation. Similarly, it is the sequence of amino acids in an enzyme which defines the secondary and tertiary structure of the macromolecule, and this overall shape enables the enzyme to "fit" the reactants and so act as a catalyst for that specific reaction.[6] Without this precisely defined structure the enzyme loses its specificity towards the substrate and hence its catalytic activity.

Matter, Space and Time Provide Overriding Constraints

The hypothesis that the macromolecules in the first self-replicating system were produced by purely chemical reactions in a large reservoir of biomonomers leads to an impasse. The number of possible sequences of the biomonomers is astronomically high; in other words, the number of macromolecules that could form chemically from the same biomonomers is immense. How could those macromolecules having just the right properties for the start of replication happen to have appeared out of the enormous variety of other possibilities? Some figures are given in Table 1 which illustrate the magnitude of this problem.

A typical cell protein might contain 250 amino acids, but the number of protein chains which could be formed from the same 250 amino acids is about 10^{325}. A mixture of amino acids combining at random might produce any of these 10^{325} possibilities and the chance of formation of the particular protein required for a specific reaction in the cell is infinitesimally small. That this is a valid conclusion is shown by the lower panel in Table 1 which gives the numbers of proteins which could occupy various volumes of space. Thus the total number of proteins (M.Wt. 10^4) which could

TABLE 1

Total numbers of different proteins or nucleic acids resulting from random combinations of 20 amino acids or 4 nucleotides.

No. of Amino Acids in Chain	Description	Total No. of Protein Chains Possible
10	Short Polypeptide	10^{13}
100		10^{130}
250	Typical Cell Protein	10^{325}
1000		10^{1301}
No. of Nucleotides in Chain		**Total No. of Nucleic Acid Chains Possible**
77	Transfer-RNA	10^{46}
1,500	Ribosomal-RNA, 16S unit	10^{903}
3,000	Ribosomal-RNA, 23S unit	10^{1806}
6,000	RNA of TM-virus	10^{3613}
30,000	Bacterial DNA	$10^{18,100}$

	No. of Protein Molecules of M.Wt. 10^4
Which could pack into total volume of universe	10^{103}
Which could pack into 1 m thick layer on surface of earth	10^{41}
In a 10^{-3} molar soup in all oceans	10^{42}
Produced by 1 cm thick layer of cells covering earth's surface in 10^{10} years	10^{52}

Table adapted from M. Eigen[20]

pack into the volume of the entire universe is only 10^{103}, and the number of proteins which could exist in a 1 metre layer on the surface of the earth or in a "soup" in the ocean is about 10^{42} or less. These numbers are over 200 orders of magnitude less than 10^{325} and are almost infinitesimally small in comparison. A rather similar situation prevails for nucleic acids. The number of possible sequences which could be formed by random combination of nucleotides is so large, even for quite short macromolecules (see Table 1), that even if the whole world consisted of a reacting mixture of nucleotides, the chances of formation of any particular sequence required for the first self-replicating organism is effectively zero in one billion (or ten billion) years.[7]

The problem is actually more serious than this because chemical reaction of amino acids or nucleotides, unlike the biochemical process, does not necessarily lead to *linear* sequences of the biomonomers. Some of the amino acids contain acidic or basic groups in the side chain R which can link with other amino acids thus forming branches in the macromolecule. The nucleotides contain reactive positions in the sugar molecule and in the base which can lead to branching or other non-biologic structures.

The nucleotides and most of the 20 amino acids also contain chiral centres, so that for each sequence of optically active biomonomers a very large number of stereoisomers could be formed by chemical reactions. In existing self-replicating systems only one of these optically active stereoisomers is effective. When these two factors are taken into account it is apparent that the total number of possible chains given for proteins or nucleic acids in Table 1 represents only a small fraction of the macromolecules that could result from chemical combinations of the monomers.

These fundamental considerations show that there is insufficient space and too little matter in the known universe and that 10^{10} years, the oft-quoted age of the universe, is not enough time for a self-replicating system similar to known biologic structures to have arisen by purely random chemical combinations.

The Literary Monkey Analogy

An analogy suggested by Cairns-Smith in his thought-provoking book *The Life Puzzle* illustrates this conclusion most effectively.[8a] A protein molecule can be viewed as a message written in a 20-letter alphabet; and equally a DNA molecule would then represent a message written in a four-letter alphabet. We can consider a message such as: A MERRY HEART MAKETH A CHEERFUL COUNTENANCE, which is written in the 26-letter Roman alphabet, and ask how long it would take a monkey hitting one key per second at random on a 30-key typewriter to produce this 37-letter message. The monkey would hit on a given letter about once every 30 seconds, so the waiting time for the 37-letter message would be 30^{37} seconds, i.e., about 10^{52} years. The waiting time for random production of protein or nucleic acid messages consisting of hundreds or more units would be correspondingly longer, and it is clearly out of the question for a universe only 10^{10} years old.[9]

If the monkey were supervised by a "selector" which could recognise the value of each symbol as it was typed and place it in the correct position in the message, then the waiting time could be dramatically reduced. A selector which could recognise words and arrange them in the right sequence could complete the message in less then 6×10^{6} years. And if the selector could pick out each letter as typed by the monkey, the waiting time would be about 20 minutes. Since living organisms containing particular, highly defined messages in protein and nucleic acid manifestly do exist on the earth, some kind of "selection process" must have operated in their construction and organization.

Not only must the selector have been capable of evaluating the potential usefulness of each macromolecule, but it must also have been able to feed back directions to the chemical synthesis process so that the desired

products were preferentially formed. This is because purely random synthesis working amongst such an immense number of possibilities could not unaided turn up enough of the required macromolecules. For example, if the entire earth consisted of a-amino acids joined in random 50-unit chains which were mutating at the rate of one amino acid per second, then a 100% efficient selector, which could not influence the mutation process, would only be able to collect about 40 to 50 molecules of one particular 50-unit protein in a period of 5×10^9 years.[8b]

Equilibrium Thermodynamics and the Origin of a Self-Replicating System

A second approach to the problem of the origin of life is provided by the science of thermodynamics. The second law of thermodynamics asserts that the universe is tending towards maximum entropy. The entropy of a system is a measure of the amount of disorder or randomness prevailing in the system. The validity of this law has been demonstrated by numberless empirical experiments and observations, and it finds daily use for correlating and interpreting data from virtually every area of science. The second law of thermodynamics rests in a particularly secure theoretical framework because von Neumann proved it to be a consequence of quantum mechanics,[10] and it also finds a striking parallel in the field of information theory.[20]

The entire incompatibility of this tendency towards maximum disorder, as observed in physical and chemical processes, with the spontaneous organization of matter into more and more complex hierarchies, as required by the evolutionary theory of the origin of life, has been noted by numerous theoreticians.[5, 11, 24, 29]

The laws of thermodynamics are statistical in nature and therefore do not *forbid* any type of process, but give predictions as to the likelihood or probability of the given process. Some have concluded that although equilibrium thermodynamics indicates high improbability for the spontaneous origin of life, it is not too implausible to suggest that the event might occur in such a long time span as a billion or so years. The thermodynamic calculations published by Morowitz[11] effectively show that this is totally unjustified. Morowitz considers a sample of close-packed living cells which are heated high enough to destroy all chemical bonds and break up the cells into their atomic constituents. The sample is allowed to cool, aged indefinitely, and then subdivided into volumes the same size as the original cells and containing the same atoms. The probability P_1 that one of these subdivisions be in a living state was then estimated by two methods based on equilibrium thermodynamics. In the first method an upper limit P_1 (max) was calculated from the difference in bond energies of the living

state and the ground state. In the second method the free energy of formation of the macromolecular constituents of cells from simple biomonomers, and other organic reactants, was estimated. Some of Morowitz' results are shown in Table 2.

TABLE 2

Equilibrium thermodynamic calculation of the probability of spontaneous formation of some macromolecular and self-replicating systems. After Morowitz.[11]

System	Description	P_1 (max)	P_1 (max) $\times 10^{134*}$
Escherichia Coli	Bacterium, wt. 10^{-12}g	10^{-1011}	10^{-1011}
Mycoplasma Hominis	Cell, wt. 2×10^{-13}g	10^{-109}	10^{-109}
T2 Phage	Virus	$10^{-2\times108}$	$10^{-2\times108}$
Hemoglobin	Protein	$10^{-4\times104}$	$10^{-39,866}$
RNA		10^{-8000}	10^{-7866}
Amino Acid		10^{-60}	10^{+74}

Probability of spontaneous synthesis of a cell in an ocean of monomer units, calculated from free energy of formation of cell constituents.

Cell Mass g	Description	Probability
10^{-10}		$10^{-3.4\times1012}$
10^{-11}		$10^{-3.4\times1011}$
10^{-12}	Typical Bacterium	$10^{-3.4\times1010}$
10^{-13}		$10^{-3.4\times109}$
10^{-14}	Smallest Known Cells	$10^{-3.4\times108}$

*The quantity P_1 (max) $\times$ 10^{134} gives the upper limit of probability that one such system could have formed once in the history of the universe.

The upper and lower panels give estimates calculated by the two methods, and the agreement between them is very good. The probability of spontaneous synthesis of the smallest cell (or virus) turns out to be unimaginably small in an equilibrium situation. To obtain the probability that a cell (or other structure) would occur spontaneously once in the history of the universe, P_1 (max) is multiplied by 10^{134}. This factor is obtained by allowing all the atoms in the known universe (about 10^{100}) to react at the maximum rate of chemical processes (about 10^{16} sec^{-1}) for a time of 10^{10} years. However, this factor is negligible in comparison with probabilities as small as 10^{-1011} and leaves them unchanged. When numbers as infinitesimally small as P_1 (max) are encountered, no amount of ordinary manipulation or arguing about the age of the universe or its size can suffice to make it plausible that such a synthesis could have occurred in an equilibrium system.[11] The same type of calculation can also be used to estimate the maximum-sized macromolecule which might be expected as a result of random synthesis. In a mixture the size of the universe, reacting for over a billion years, this turns out to be only a small polypeptide.[11]

These calculations illustrate the immense amount of organization that went into the production of the first living system. Equilibrium thermodynamics, like statistical mechanics, points unmistakably to the conclusion that purely random chemical combinations cannot account for the origin of life. In fact this idea has now been almost wholly abandoned (except in elementary texts). It is recognised that some "principle of organization," "selection factor" or "design mechanism" must operate, or have operated, in the past. Crick believes that the necessary organization was the outcome of Darwin's principle of natural selection,[3] Morowitz,[11] and others, consider that non-equilibrium thermodynamics can supply the answer, Cairns-Smith[8] voices the opinion that self-organization is an inherent property of certain molecular aggregates and macromolecules, Elsasser[12] and Polanyi[13] champion the view that some aspects of biological systems cannot be accounted for in terms of the presently known laws of physics. Before turning to a consideration of these theories of self-organization, we will examine the second problem theoretical physics poses in the field of living structures.

THE RELIABILITY AND STABILITY OF BIOLOGICAL STRUCTURES

A characteristic property of living matter is its ability to reproduce itself virtually without error for an indefinitely large number of generations. Monod lists this reproductive invariance as one of the three general properties of living systems which sets them apart from inanimate matter.[14] The problem that this remarkable reliability and stability presents to physical theory was first clearly set forth by Schrödinger in his fascinating little book *What is Life?*[15] The problem has become even more of an enigma as the modern advances in molecular biology have revealed the details of how cell reproduction and metabolism work.

Mechanistic Explanation of Cell Function

Basically the present-day explanation of cell function is a mechanistic one. That is, the molecular components of the cell work in essentially the same way as the mechanical parts of man-made machines. The highly specific function of enzyme catalysis, for example, is understood as the same type of operation to that of a machine tool in a production line. Similarly, the process of replication is compared to a template copying procedure, and the operation of allosteric enzymes in cell control processes is similar to that of a ball-valve or mercury relay.

The almost unlimited reliability of organisms is already remarkable when we compare them with macroscopic machines all of which wear out, wind down, or go wrong. No real system can operate without statistical errors. Even really immense machines such as the solar system wind

down eventually because of tidal friction, solar wind effects and so on, but for macroscopic machines in general, the smaller the size and the higher the speed the greater is the error rate.[5] The cells of living organisms are incomparably smaller than any man-made machines and yet they function with unprecedented reliability and stability.

Random Motion of Molecules and the Statistical Nature of Physical Laws

This phenomenon becomes all the more striking when it is appreciated that all the properties of living beings are based on a *fundamental mechanism of molecular invariance.*[14] That is, the components of living machines are molecules. In some organisms the genetic information and the process of replication depend on a single macromolecule; other cell functions depend on collections of molecules containing very few members. Apparently a single molecule, or group of a few molecules, can, in a living system, produce orderly events according to well-defined mechanisms which are highly coordinated with one another and extremely error free. We are faced here with a situation entirely different from that prevailing in the world of physics and chemistry. Individual atoms and molecules in inanimate matter never behave in this way. Outside of biological systems, atoms and molecules undergo random thermal motion so that, even in principle, it is impossible to predict the behaviour of individual particles (except at absolute zero). The only law individual atoms and molecules obey is that of pure chance or random fluctuation. For this reason the fundamental laws of physics and chemistry such as quantum mechanics, thermodynamics, or kinetics are statistical in nature. Thus although individual molecules behave in a random manner, the average effect of an immense number of molecules (say more than 10^{20} for most macroscopic systems), when acted upon by particular external constraints or boundary conditions, can be a highly exact law.

When a chemist studies the reaction of a very complex molecule he always has an enormous number of identical molecules to handle. He might find that 30 minutes after he had started some particular reaction half the molecules had reacted, and that 30 minutes later three-quarters of them had done so. This kinetic law applies only to the huge collection of molecules; whether any particular molecule will be among those which have reacted, or those that remain, is a matter of pure chance.

Imagine a small amount of powder consisting of minute grains, such as lycopodium, poured onto the surface of a liquid and then observe one of the grains under the microscope. It is found to perform an irregular random motion known as Brownian movement. These grains are suffi-

ciently small to be susceptible to the random impacts of single molecules in the fluid. The motion of a single grain is again unpredictable, but if we have a sufficiently large number of grains the statistical average behaviour gives rise to the well-ordered phenomenon of diffusion.

This is not a purely theoretical speculation; it is not that we can never observe the fate of a single atom or molecule. In the case of radioactive disintegration, for example, it is possible to observe the break-up of individual atoms. It is found, however, that the lifetime of a single radioactive atom is entirely uncertain; it might break-up at any time. The appropriate averaged behaviour of a large collection of identical radioactive atoms results in the exact exponential law of decay.

The most fundamental of all physical theories, quantum mechanics, tells us that this phenomenon of individual indeterminancy reaches even deeper than this. The very components of the molecules themselves, i.e., electrons, protons, neutrons, etc., are not simple particles which work in a mechanistic way like the parts of a machine or miniature solar system. Their regular behaviour can also be described only in a statistical fashion by means of a "wave function" which has to be averaged in the appropriate manner to obtain any given property.

The basic paradox therefore, as Schrödinger realised as long ago as 1944, is this: in inanimate matter regular, orderly behaviour is always the averaged result from a very large collection of molecules acted on by particular constraints. In living matter, however, orderly behaviour appears to result from the activity of single molecules or very small collections of molecules. The fundamental physical laws lead us to believe that single molecules should behave in a random manner and yet in the cell all the hereditary rules are executed with incredible speed and reliability using single molecules.

Modern theoreticians such as Pattee[5] and Bohm[16] have discussed this problem without finding any satisfactory solution. Bohm emphasizes that it is practically certain we cannot understand the transmission of genetic information in terms of fundamental theory and comments on the odd fact that just as physics and chemistry are abandoning mechanistic interpretations, biology is moving over towards them. He concludes:

> *If this trend continues, it may well be that scientists will be regarding living and intelligent beings as mechanism, while they suppose that inanimate matter is too complex and subtle to fit into the limited categories of mechanism.*[16]

Some authors attribute the reliability of cell replication to the functioning of the powerful repair mechanisms.[3] This is almost certainly inadequate as an explanation because the physical laws imply essentially random behaviour for single molecules. In addition to this difficulty, the repair

mechanism would have to "know" the original structure in order to restore it. If the original molecule under repair were the genetic DNA, the repair mechanism would have to possess, or have access to, another copy of the original. Yet in some organisms the DNA is present in only one or two copies.

Error-correcting devices have been studied in detail by computer theorists amongst whom there is universal agreement that the only way deterioration of the information can be prevented, or at least reduced, is by means of redundancy; that is, the presence of the same information several times over. The lower the desired error rate the greater the number of copies required, and hence the larger the machine.[12]

Quantum Mechanical Calculation of the Probability of the Existence of Self-Replicating Systems

Some years ago Wigner[17] also arrived at the conclusion that the reliability of the replication mechanism of living organisms cannot be understood in terms of physical laws. Wigner's approach was a direct application of the quantum mechanical method in a calculation of the probability of the existence of a self-reproducing unit. He considered the interaction of a living system with a nutrient to produce another identical organism, the final state consisting of the two organisms and the remainder of the nutrient. This interaction was assumed to be purely random, i.e., to be governed by a random symmetric Hamiltonian matrix. On counting up the number of equations determining the interaction, he found this greatly exceeded the number of unknowns which describe the final state of the nutrient plus the two organisms. Wigner's analysis showed that it is infinitely unlikely that there be any state of the nutrient which would permit multiplication of the organism. As he puts it, "it would be a miracle" and would imply that the interaction of the organism with the nutrient had been deliberately "tailored" so as to make the lesser number of unknowns satisfy the greater number of equations.

Wigner was careful to point out that his conclusion is not truly conclusive. The most important assumption on which it is based is that the interaction of the nutrient with the organism be governed by a random symmetric matrix. This assumption may, of course, be questioned, but its entire reasonableness is demonstrated by the fact that an identical assumption for the Hamiltonian matrix of complicated systems enabled von Neumann to prove the second law of thermodynamics to be a consequence of quantum mechanics.[10]

Landsberg[18] reexamined the application of quantum statistics to the question of the spontaneous generation and reproduction of organisms.

Using a different formalism he confirmed that Wigner's assumption leads to practically zero probability for both spontaneous generation and self-replication. If, however, the assumption is broadened to include non-equilibrium systems the probabilities, though small, become greater than zero. So quantum mechanics neither forbids nor excludes the existence of life, but it does suggest that life could not arise or reproduce as a result of the random interactions encountered in inanimate matter. The implication is that some hitherto little understood "principle of organization" must operate in living matter to generate an ordered distribution in which the interaction is somehow "instructed."

CONTEMPORARY THEORIES OF SELF-ORGANIZATION

Neo-Darwinian Natural Selection

The widespread recognition of the impossibility of formation and continuance of self-replicating organisms from purely random combinations has led to a good deal of speculation about the nature of the organizing power or principle which must be involved. Crick, along with many others from the field of biology, considers that the neo-Darwinian mechanism of natural selection provides the answer.[3] A necessary condition for this mechanism is the *prior existence of an entity capable of self-replication*. Variants are then produced in its genetic material (by mutations for example) and then copied by a passive synthesizing process. Environmental pressures then bring about the dominance of the entities with the greatest probabilities of survival and reproduction.

The weakest point in this explanation of the origin of life is the great complexity of the initial entity which must form by random fluctuations before natural selection can take over. It must carry the information for its own synthesis in its structure and control the machinery which will fabricate any desired copy. What is the simplest entity capable of fulfilling these conditions? Haldane suggested a short polypeptide of low activity and specificity,[19] but even this is too complex, because as shown above and as Haldane himself pointed out, the chances of random synthesis of one particular protein are effectively zero. In fact most authors who have considered this question have concluded that neither proteins nor nucleic acids alone possess the requisite properties for self-replication and that a combination of the two types of macromolecules is required.[20,21]

Doubts have also been expressed about the efficacy of the natural selection mechanism itself. There is nothing in neo-Darwinism which enables us to predict a long-term increase in complexity, because greater probabilities of survival and reproduction do not imply greater complexity.[22] Neo-Darwinism also fails to account for the grosser changes of organisms

such as epigenesis.[22] Mathematical models of the neo-Darwinian mechanism show that the probability is zero for selection operating in one space (the phenotype) to bring about coherent changes when random mutations are performed in the first space (the genotype).[23]

Non-Equilibrium Thermodynamics and Self-Organization of Matter

Prigogine,[24] Morowitz[11] and Eigen[20,25] have been foremost in the application of non-equilibrium or irreversible thermodynamics, which applies to "open" systems through which energy or matter flows, to the problem of self-organization. In the open part of a system a decrease in entropy or increase in order is possible at the expense of the surroundings. The first essential for an open system is therefore some kind of *structured* environment.

For example, a gas in a container in contact with a heat source on one side and a heat sink on the other side is an open system, and the simple ordered phenomenon of a concentration gradient is set up in the gas. This order depends for its existence on the structure: source — intermediate system — sink. If this structure is withdrawn, e.g., if the source is allowed to come into contact with the sink, or if the gas molecules are allowed to diffuse out of the container, the system decays into equilibrium. Another example is a crystal growing in a saturated solution in a container. If liquids are allowed to enter the container or solute molecules to diffuse out, then dissolution of the crystal begins.

The amount of order or organization induced in the open system is a consequence of the amount of information built into the structured environment and cannot be greater than this. Polycondensation of sugars to give polysaccharicles and nucleotides to give nucleic acids can be brought about with the appropriate apparatus (i.e., structure) and supplies of energy and matter. Mora has shown that the amount of order in the final product is no more than the amount of information introduced as physical structure of the experiment or chemical structure of the reactants.[26] Non-equilibrium thermodynamics *assumes* this structure and shows the kinds of order or organization induced by it. The question of the origin and maintenance of the structure is left unanswered. Ultimately this question leads back to the origin of any structure in the universe, and this is a problem for which science has no satisfactory answer at present.[27]

Eigen's development of the application of non-equilibrium thermodynamics to the evolution of biological systems is one of the most comprehensive and far reaching.[20,25] He showed that the system must be open and far from equilibrium for selection and hence evolution to occur. The reaction must also be autocatalytic in the sense that the product macro-

molecule must feed back (possibly via some catalytic reaction cycle involving other intermediates) onto its own, and only its own, formation. He recognised that self-organization must start from random events and tried to discover the simplest molecular system which could lead to replication and selection behaviour.

He considered in turn systems containing only nucleic acids, systems containing only proteins, and catalytic networks of proteins and presented detailed and well-reasoned evidence that these are unsatisfactory. The complementary instruction potential of nucleic acids must be combined with the catalytic coupling behaviour of proteins in order to produce the type of structure and function indispensable for a self-replicating organism. This necessitates the presence of molecular machinery for translating the information in the nucleotide sequences into the protein structure. Eigen suggests the "catalytic hypercycle" shown in Figure 2 as the simplest system possessing the requisite properties.

It consists of a number (minimum two) of nucleotide sequences N_i of limited chain length containing the information for one or two catalytically active polypeptide chains P_i. Each polypeptide P_i is coded for by the nucleotide sequence in the corresponding chain N_i which is translated by the molecular machinery (T). The circle around each N_i is a representation of the ability of each nucleotide chain to reproduce itself with the aid of the catalytic enhancement provided by the preceding polypeptide P_{i-1}. The hypercycle must be closed, i.e., there must be a P_n which can catalyse the replication of the nucleotide sequence N_1.

Attractive as the properties of this model are in providing for replication and selection amongst competing hypercycles, there appear to be

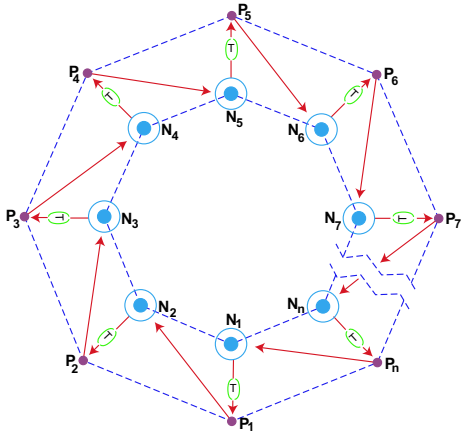

FIGURE 2. Eigen's self-instructive catalytic hypercycle. The N_i (i=1,2,3, ..., n) represent complementary single strands of RNA whose information is made available by the translation mechanism (T). The P_i (encoded by N_i) represent polypeptides having various catalytic activities such as polymerization, translation, control. The P_i catalyse the replication of the next RNA strand, N_{i+i}, in the cycle.

insuperable problems connected with the formation of the cycle from randomly reacting mixtures of amino acids and nucleotides. Statistical considerations show that the probabilities of formation are effectively zero for the particular nucleotide and protein sequences needed to carry the specific information and catalyse the specific reactions in the hypercycle, especially as they must be produced in sufficient quantities in close spatial and temporal association.

The information in the nucleotide sequence N_i for protein catalyst P_i is made available by the presence of the code translation machinery. This involves several more particular macromolecules (in present-day cells about 50 macromolecules are involved in translation alone). The origin of the genetic code presents formidable unsolved problems. The coded information in the nucleotide sequence is meaningless without the translation machinery, but the specification for this machinery is itself coded in the DNA. Thus without the machinery the information is meaningless, but without the coded information the machinery cannot be produced! This presents a paradox of the "chicken and egg" variety, and attempts to solve it have so far been sterile.[14]

Non-equilibrium thermodynamics has been useful in clarifying the essential requirements of structure and energy for organization to develop in molecular systems and in providing new insight into how organisms work. The complexity of Eigen's hypercycle or Cairns-Smith's "evolution machine"[8] and other suggested open systems destroys their credibility as the starting point of molecular evolution.

Biological Structures and "Biotonic" Laws

The impotence of the fundamental physical laws when applied to the origin and operation of biological structures has given renewed impetus to a school of thought favouring the idea that in biology new principles, as yet undiscovered in physics, are needed.

Elsasser has argued for the semi-autonomy of biology from physics on the grounds that the classes of living structures are too small for the statistical averaging procedures of physics to be valid.[12] He coined the term "biotonic laws" to describe the new principles operating in biology. Garstens postulated that a special set of auxiliary assumptions, different from those of physics, would be needed in the application of statistical mechanics to biological phenomena.[28] Polanyi emphasised the mechanism and design in living organisms and their irreducibility to the laws of inanimate matter.[13]

Mora finds support for the biotonic law concept in the impossibility of reconciling statistical and thermodynamic constraints with the spon-

taneous formation of living processes.[29] In addition to the quantum mechanical calculation discussed above, Wigner believes the phenomenon of consciousness points unmistakably to new principles operating in biology.[17] Longuet-Higgins affirms that physics and chemistry are conceptually inadequate as a theoretic framework for biology and recommends thinking about biological problems in terms of design, construction and function.[4]

Selection, Organization and Special Creation

A variety of independent applications of the objective laws of theoretical physics to the problem of living organisms, by a disparate series of scientists and philosophers, has disclosed the presence of "selection," "instruction," or "tailoring" in their make-up. Conventional scientific theories of origins have reached a stalemate situation where on the one hand theory and practice show that self-replication is essential for "selection" to occur. But on the other hand, without selection the formation of a self-replicating system is infinitely unlikely. How can this closed loop be broken? Exactly the same situation is encountered with inanimate machines, but here the "selection" or design was supplied from outside by the builders or designers. The indications of design at the molecular level and the analogy from machines are suggestive of external intervention in organisms.

The fundamental postulate of special creation is that living structures were built by an outside agency, i.e., the Creator. The highly unlikely organization of the atoms and molecules in the cell can be reconciled with statistical mechanics if they were deliberately synthesised and arranged by an external agency. The best analogy to this agency that we have is man, and he, working in the laboratory, can synthesise molecules or machines in imitation of nature or of entirely novel formula, which pure chance working with the matter, space and time available on earth could not hope to devise.

The spontaneous generation of biological structures runs counter to the second law of thermodynamics. This contradiction disappears when we consider the structured system: creator — material — organism, where the organism is an "open" part, like the artifact in the system: man — material — artifact. A decrease in entropy, i.e., an increase in organization, in the open part of these systems is entirely consistent with the second law.

Wigner's application of quantum mechanics to the replication process implied that "tailoring" of the unknowns to the equations must have occurred in the interaction of the organism with the nutrient. The "principle of organization" at work in this process of instruction might then be

identified with the design activity of the creator. It is tempting also to interpret the unprecedented reliability and stability of living organisms to the repair or sustaining activity of the creator. As usual in biology, a mechanical analogy clarifies the situation. Consider an automatic lathe manufacturing a stream of screw-threaded bolts. The uninstructed interaction of the machine with the bolt might take an infinite number of different forms, but the geometry and design of the machine have been tailored so that the cutting tool bears on the bolt for the exact time and with the exact angle and travels the precise distance needed to cut the thread. However, without the constant attention of service engineers the reliability of production would soon deteriorate.

The underlying similarity and unity of biochemical processes imply that life originated only once. The universality of the genetic code and the prevalence of only one optical isomer of biological molecules (such as the L-isomers of amino acids) point to the same conclusion. This is certainly comprehensible in terms of the special creation postulate. Furthermore, the paradox of the origin of the code is removed if the nucleotide sequences were designed and fabricated to couple with the translation machinery and built at the same time. The origin of the code would then be analogous to the origin of Esperanto or Algol.

Outside of the fundamental postulate, special creation violates none of the basic physical laws. It generates none of the contradictions and paradoxes encountered with the molecular evolution hypothesis. It cannot be claimed that creation "explains" the origin and continuance of life. Obviously it transforms the question to one on the nature and continuance of the creator. However, molecular evolution fares no better in this respect, because it simply transforms the question to the origin of structure, matter and energy in the universe.

The postulate of creation of living structures by external intervention undoubtedly restores order, harmony and simplification to the data of physics and biology. At present there is no unambiguous evidence of a scientific nature for the existence of the external entity, but this should not be regarded as a drawback. Many key scientific postulates such as the atomic theory, kinetic theory or the applicability of wave functions to describing molecular properties were, and still are, equally conjectural. Their acceptance depended, and still depends, on the comparison of their predictions with observables. The value of any given postulate lies in its ability to correlate, simplify and organize the observables. Judged by this standard special creation suffers from fewer disadvantages than any alternative explanation of the origin of life.

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ENDNOTES

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ARTICLES

DOES GOD PLAY AT DICE?

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WHAT THIS ARTICLE IS ABOUT

This article addresses itself to the tension that develops between naturalistic and theistic explanations in the context of unpredictable events such as those of quantum mechanics, man's free will, and God's creativity. The author feels that there is purpose in novelty or free choice in at least all these cases. In the case of man, God has voluntarily given up some of His omnipotence to permit man to have free choice. This view is superior to pure determinism in that it recognizes bona fide sources of novelty in the world and adds meaning to man's search for understanding.

INTRODUCTION

For most of us there is a tension between the naturalistic and the theistic view of the relations between things and events. For the naturalist the universe is a vast system or process, self-contained and self-consistent, with every thing and every event explicable (in principle) in terms of other things and other events belonging to the system. The theist holds to the idea of a God who is apart from the world and yet on whom the world depends for its existence and to whose will it is responsive. The tension, if I am correct, is part of the cultural heritage of Western man. It is particularly acute for those who subscribe to theism and practice crafts, like those of the scientist or historian, primarily concerned with the development of naturalistic explanations.

Since the seventeenth century the view of the world most frequently held is one that might be called "Newtonian" after its similarity to Newtonian mechanics. In this naturalistic pattern, all future events flow out of the present and are uniquely determined by the present. In a real sense there are no surprises in the Newtonian world since every event follows inexorably from other events.

Laplace expressed the Newtonian idea in a particularly impressive way that has become part of the myth of the original idea. He supposed there was a mathematical demon of infinite computational capacity, something far beyond even the most powerful computers of the present day. He claimed that with such a demon at hand he would only need to know the exact position and velocity of every particle in the universe at a particular instant to be able to determine the state of the universe at any other time, past or future. The entire history of matter is interlocked in such a manner, according to this ideal, that it is inevitably unique. That such a demon could not exist is not an argument against Laplace's idea, as

the statement is not about computability but about the relations of determinism.

It is difficult to make the Newtonian model harmonize with the ideas of theism, for a well-determined and self-consistent sequence of events can hardly be influenced from the outside without a serious disruption. And much of the conflict between scientific and religious thinking about the world in the post-Newtonian era can be traced to this difficulty. God can be seen as the creator of this vast machine and even the one who gives it initial direction, but He enters the stream of events only as an alien and a disrupting influence.

The twentieth-century physics of quantum mechanics stands apart from the Newtonian ideal in that the events of the future are not uniquely determined. The potentialities for a variety of futures exist in the present and although the question of God's relation to the whole remains unanswered, it is clear that it must be answered in fundamentally different terms than in an earlier era. It is the purpose of this essay to attempt the expression of the problem in terms and concepts common to twentieth-century physics. It would be optimistic to expect a solution to the fundamental question to result from the change of physical worldview, but refreshing insights may follow from the endeavor.

The first, and I believe the only, person to attack the problem outlined was William Pollard, who in *Chance and Providence* attempted to bring the worldviews of theism and quantum physics together. In what follows I will be depending heavily upon his work. If I take exception to his views at times, I believe I am still within the basic spirit of his approach. The terms used (and to a large extent the categories) are those introduced in his work. "Providence" usually implies a relation between God and the world rather than any specific act. "Chance" as he uses the word describes an event that is not uniquely determined by its antecedents. The "accidental event" is for him one that occurs at the coincidence of two or more causal chains.

What begins as a nuclear physicist qua theist looking at the Biblical view of providence becomes a historiography, where the random events are not those of atoms but of men; but the openness of a world where chance events may occur is required if one is to posit a God active in history.

> *The key to the Biblical ideas of providence, and therefore to providence in the form in which we as Christians perceive it, is to be found in the appearance of chance and accident in history* (Pollard, p 66).

In Pollard's view what is seen as accidental in the scientific or historical view of reality may with equal validity be seen as providential from the Biblical view and these two apparently contradictory perceptions are two aspects of a single total reality.

THE BIBLICAL VIEW

There are two fundamental concerns of cosmological thought on which the Bible clearly speaks and where its statements guide us in our thinking. The Scriptures are clear in expressing a basic theism in describing God's relation to the world of things. He creates the world from nothing. He passes judgment on it. The world is sustained by Him and is subject to His will both in a general way and in specific cases. It, however, does not reflect His immediate will in all things. Man, as he appears in Scripture, stands between. He is part of the created world of things, but is given responsibilities that transcend the rest of nature. He is able to make judgments and to introduce novelty. He is subject to a world of nature as part of it, but makes choices and takes actions that do not flow uniquely out of the situation. He is held responsible for these actions.

Whereas the Biblical views of God and man do not speak directly on our subject, they supply a reference point. They reject what Pollard describes as the tended-machine idea that grows out of Newtonian mechanics and that ends by eliminating the possibility of God acting in the world.

> *...we have come to think of our world...as a vast and intricately complex mechanism unfolding inexorably in accordance with fixed and timeless laws defining its behavior down to the most intimate detail. The relation between God and nature, if acknowledged at all, has been reduced to that of the deus ex machina who, having initially brought the world into existence and endowed it with a certain structure regulated by a complete system of scientific law, has ever since stood wholly apart from it (*Pollard, p 19).

Against this idea, he expresses the following as the Biblical concept:

> *The idea of a nature which was capable of running along on her own course apart from God even for a short time is entirely foreign to Biblical thought. Providence in the Bible is a continuous relationship of dependence of both man and nature on God of such mutuality and intimacy that the latter could not continue at all if ever the relationship were broken* (Pollard, p 27).

This latter quotation is an expression of the apostle Paul's "In Him we live and move and have our being" (Acts 17:28). Our immediate interest is to discover compatibility between the Biblical view of God's action and the view commonly held by quantum physicists of the statistical nature of events. The task is undertaken with full confidence in both the basic theistic views and the meaningfulness of scientific and historical activity. The synthesis sought is one that includes a purposive God, ever active in the whole of creation, and that preserves the essential integrity of science.

THE QUANTUM VIEW

In twentieth-century physics a completely new set of ideas associated with quantum mechanics has become dominant, contested from every

side, but still the working faith of a large part of the physics community. It is this set of ideas that I will suggest may be compatible with the Biblical view of providence and with God's continued action in a world apart from Him.

Within the theory of quantum mechanics are several features that merit attention. First, there is the basic statistical nature of the event. The consequence of a quantum calculation is always stated in terms of probabilities. The probability of quantum mechanics is not a consequence of complexity or of lack of knowledge, but is fundamental and at the heart of the matter. The consequence of any set of conditions is not uniquely described but always given as a probability statement on a set of possibilities, and there is no set of more precise measurements that is ever going to make it more than this. It follows that the demon could not uniquely specify the future of even the simplest system, but only the possibilities for the future, and this is clearly far from Laplace's ideal, as the future is now open in a real sense. This does not indicate that the future is completely open to any possibility, as a number of rigid conservation rules determines the possibilities and their relative probabilities. They, however, do not determine the specific event that will take place at any instant.

Secondly, the principle of uncertainty (indeterminacy) describes the limitations on the knowledge available about a physical system as a result of any single set of measurements. In physical terms either the energy or the time of the event may be known, but if the energy is specified more precisely, it results in the time being known less precisely. This limitation is also true for knowledge about the position and velocity. This places a fundamental restriction on the knowledge available about the system. Laplace's demon would be hamstrung before commencing his calculation by a lack of complete information.

Taken together, what the statistical event and the uncertainty principle reveal is a world that is open at its most fundamental level in the sense that the future is not uniquely determined by the present state of affairs. This was identified by the term "chance" at the beginning. I cannot emphasize too strongly that this chance is not the same as that experienced in events such as rolling dice, where it is in theory possible to know the outcome, if sufficient care is taken. In this case, the statistical nature of the event is at the heart of the matter.

It is at this point that many persons, including Einstein, reject the statistical interpretation of quantum mechanics. Can the world be statistical and open at its most fundamental level? The question is in a sense still open, for there is not universal agreement about the foundations of physics. But the weight of current evidence and opinion favors a statistical view, which at this level implies an open system. The next question is what this means for our broader worldview.

OTHER SOURCES OF NOVELTY

From the beginning of deterministic modern science there was no suggestion that man was completely determined. Descartes spoke of animals as automatons in the sense of being machine-like, but man was seen as something apart, capable of taking self-generated action. As the ideas of determinism became more thoroughly developed, however, others insisted that man is also part of deterministic nature. We see the culmination of this tendency in the behavioral psychology of the present era. It is, to say the least, ironical to see the result of an *idee fixe*, discarded from the world of physics, held to religiously in a field where there was little reason to adopt it in the first place.

We see no reason to doubt that even though man is subject to a multitude of determining forces and is in many ways determined, he still makes choices, takes action, and is a source of genuine novelty in the world. There is certainly as much empirical evidence for this generalization as for any made in the field of physics. The honest skeptic will continue to raise valid questions, but if he looks critically at the fundamental principles of physics, he will find them at least as dubitable as the ideas that he questions about man. Opposition to the idea of man as an originator of genuine novelty comes from both sides. Believers in deterministic materialism reject it as in some sense placing man outside of an otherwise complete natural world. Those who subscribe to the idea of an omnipotent God reject freedom for man as in some way encroaching on God's prerogatives. The two objections, from opposite poles of thought, are similar in that they each view the idea of man's freedom as a violation of a monolithic view of reality, and we can only ask for a critical, open-minded examination of the evidence in science, in history, and in Scripture.

The comparison between the behavior of physical systems and historical events at the level of man's action is certainly a giant quantum jump and must not be understood in terms of the latter being derived from the former. If either or both are genuine, they must stand on their own merits. Pollard sees the connection, or parallel, between the two as lying in the irreversibility shared by all events subject to the second law of thermodynamics and the irreversibility of history. He is here relying upon a distinction made by Weizäker between scientific and historic time: "With the second law...it can be proved that the world is a sequence of events incapable of repetition" (Weizsäker 1951, p 49-50). In this context, the term historic time refers to any irreversible sequence, whether the concern is historic or scientific.

In developing the analogy Pollard depends heavily on Handlin's argument that the development of history is open to chance and accident. To Handlin the chance event or the accident is often the key to "understanding" history, and since he suggests that the workings of providence

may "be seen" in these turns of history, the idea is ready at hand for Pollard's use. It should be made clear that he is not suggesting either: 1) at the level of random events, God in some sense mechanically contrives the outcome either for atoms or man, or 2) God manipulates the probabilities so that the outcome is certain or more certain. Although Handlin may in fact be saying something like one of these, what Pollard is saying is more basic and deals specifically with our understanding of events.

In the following quotation the idea of complementarity is evidently applied:

> *Science deals with repeatable events for which the laws of nature determine probabilities of occurrence. Providence in the Biblical sense deals with isolated singular events apprehended in a given historical context as responsive to God's will. One and the same event can equally well be regarded as under the full sway of all laws of nature and natural causality and at the same time under the full sway of the divine will* (Pollard, p. 94).

He clearly believes that to perceive events as the working out of God's will requires the insight of revelation:

> *The methods of science can never penetrate beyond chance and accident to discover any evidence of providence, and at the same time how and why it should be that the hand of God in history can only be known ... through revelation.... one and the same sequence of events can be apprehended by one observer as merely a remarkable streak of luck while being recognized by another for what it really is: a mighty act of the living God* (Pollard, p 171).

As he describes the two ways of looking at reality, insisting that both are true but neither is truth, it is clear that the idea of complementarity (it may be necessary to look at the same event from two different points of view to extract all its possibilities) is as precious to Pollard as it was to Bohr. The scientific worldview and the theistic worldview are necessary complements to each other.

It is apparent that there are at least three different sources for novelty: God, man, and the quantum event. It remains to explore what the consequences are and what they say about God's relation to the whole.

A PURPOSEFUL WORLD

Is there any way in which the history of such a statistical world, or the world itself, can be described as purposeful? To answer the question we must first explore the idea of purpose for its meaning. If "purpose" means an inexorable movement toward some unique end, it appears that the openness of the statistical event denies that possibility. If purpose attaches to things rather than to events (e.g., the watch marks time for man, the purpose of the sun is to warm the earth, etc.), it is not clear that the statistical concept has anything particular to say about it. Things may, or may not, have unique functions that serve some central purpose.

Let it be assumed, however, that the statistical nature of events itself serves some general purpose. A case can be made for this in the following way. Suppose that the purpose is not in the end, but in the doing. It is possible from this point of view to see within the statistical world opportunity for purpose to be achieved. If to provide a future open to novelty, to have a world with a rich variety of possibilities and situations, to allow opportunity for creatures to act responsibly serves a purpose, then it appears that the statistical world can be thought of as fulfilling this purpose.

In this connection Bronowski distinguishes systems as topologically open or closed, bounded or unbounded:

> *A bounded plan is a rational sequence of instructions which have been framed to reach an announced end. If the end state is the same as the state at the beginning, the bounded plan is also closed; but in either case, so long as the end state is fixed in advance, the plan has the finite and prescribed character that makes it equivalent to an instruction* (Bronowski 1969, p 73).

A topologically open and unbounded plan is one in which the end state is not unique nor are the steps by which the end is attained completely specified. In his view there are degrees of both openness and boundedness from the simplest physical systems, to the world of man. "Unbounded" as used here is equivalent to the "open" that we used earlier. In Bronowski's words the world as we perceive it is following an open, unbounded plan. "Only unbounded plans can be creative," for the bounded plan is always the solution to a specific problem. The case being made is that the unbounded character of the world is founded on its basic statistical character. No one is suggesting either complete unboundedness or complete openness. There remain within quantum mechanics, as in history, impossibilities as well as possibilities. In physics it is a striking fact that the strongest laws are statements of impossibility, "the postulates of impotence." Systematic formulation of the impotence postulates for men does not exist, but we are all conscious of our impossibilities. Open-unbounded plans may still have a structure, but it appears as a structure on the statistics.

Neither is it being claimed that randomness at the quantum level is the basis for the randomness at higher levels. This may or may not be true. The assertion that we are making is less than that of Bronowski who sees novelty at all levels, but is compatible with it. The claim is only that there is reasonable evidence for novelty at at least three levels and that this openness to novelty is perceivably purposeful.

OBJECTIONS

Einstein's profound dissatisfaction with the statistical view of quantum theory and his numerous attempts to break the Copenhagen-Born interpretation and to produce an alternative are well known and reminds us of his

question of whether God plays at dice: "Der Herr Gott würfelt nicht." He was, and is, not alone in his feeling about the theory, and others continue to challenge the statistical view. If, in fact, the statistical view and the uncertainty principle are valid, and if at the other end of the spectrum man does act freely, it is clear that in a sense God does play at dice, i.e., the outcome of things is not uniquely determined by His will and that He relates to a world open to chance or novelty.

The concern of Einstein appears to stem from devotion to the idea of an ultimate single equation describing all physical reality. Several fundamental contributions to statistical physics and early quantum theory were made by him, but after his work on general relativity and when it became clear where quantum physics was headed, he consistently opposed its statistical interpretations.

Others have different reasons for concern. Is the order perceived at the level of our senses consonant with the disorder or chaos that follows from the statistical event? Is it possible for an overall purpose to be achieved, or for order to result from statistical events? I have spoken of a purpose to be achieved in producing a milieu for free action, but is that enough, for does the Biblical view not see the world as moving toward an end, and is this possible in a statistical world?

There are two approaches to the first question, and the second of these suggests the possibility of a response to the second question. Statistical mechanics, the mechanics of large numbers of atoms, molecules, or anything, is a well-developed branch of deterministic physics. Starting from simple statements about probabilities and proceeding in a straightforward manner it concludes with what appear to be deterministic equations governing the behavior of the system. Laboratory measurements to verify these equations give consistent results. Ought there not to be large fluctuations on any single prediction if the fundamental event is random? No, not so, for there is a central tendency in the statistics, and for large numbers this is extremely sharp and the fluctuations relatively small. The result is that the behavior of a physical system consisting of a large number of elements is predictable. The order is well defined even though it rests on a fundamental disorder. Order does, in fact, emerge from chaos as a result of the central tendency of the statistics of large numbers.

Order comes out of chaos also in quite another way in the growth of a crystal and in the nourishment of a living cell. In each of these the random motion of molecular events is a necessity if the process is to continue, i.e., for the crystal to grow or for the cell to continue function.

To develop the idea of a developed order in spite of a basic randomness, consider an analogy. In sending a message by telephone or in recording a scene with a photograph, it is interesting to note that the basic element in

each case is a random event. The emission of an electron from a hot filament and the photon striking a silver halide crystal are alike in that there is no way of determining when the electron will be emitted or where the photon will strike. The sound of electrons leaving a filament is quite like the sound of rain on the roof and the statistics of photons striking film the same as that of raindrops hitting pavement. By modulating these events, in time for electrical signal and in space for the optical, the result is a coherent message and a replica of a scene. From this it is clear that order and useful ends can be achieved starting from random events. The analogy is applied by supposing that something like modulation occurs in the world as a result of God's action. Without changing the statistical character of the free act or the quantum event, the overall pattern of events is ordered and purposeful. What is required to achieve that modulation when the effective agent is God's will is not clear nor is it expected that it will ever be clear to us. It appears wise to stay completely away from any attempt to construct a mechanism and ask only if the ideas are self-consistent.

CONSISTENCY

If the ideas that have been developed are to be tested against Scriptural concepts, the best that we can expect is a general harmony. Certainly the Bible doesn't speak on the interpretations of quantum mechanics but it does on the affairs of men and history.

Accidents do occur, are recorded, and accounted for as accidents in Scripture. "Time and chance" are part of the view of the world, and the Bible clearly indicates that to think of God as directly involved in directing each of life's events is improper. To explain, as we often do, that "God permits" is to speak for a world that does not always follow a unique purpose and direction and is consistent with the concept of chance events. There is insufficient Biblical evidence to explain, as some do, that all events not under God's immediate direction are being directed by the power of Satan, although the world described by writers of Scripture certainly allows for direct acts of intervention both by God and Satan. "In Him we live, and move, and have our being" (Acts 17) is a statement about the most basic relation of all being. Beyond this, and after allowing for acts of intervention, the world appears to be given, by its creator and sustainer, the power of autonomy to continue as a self-functioning, self-consistent thing.

It is significant to note that something has happened to our view of God as this idea has developed. If God is omnipotent and if He creates things to which power is given, He is then no longer (as the one who objected to man as a source of novelty realized) omnipotent in the original sense. He has given up, apparently of His own volition, part of His power as a gift to the creation. In another sense it is still His, for it is held, by the

other, subject to His will. The Scriptural view of the generous, loving, giving God is consistent with this act of sharing.

If the future is truly open as would be suggested by both the statistical understanding of the quantum event and the concept of men who make bona fide choices, then again God has given up the unique knowledge of all future events we often attribute to Him. In giving to atoms their quantum nature and to man the power to choose and act, He has allowed creative acts, of which He is the sustainer, that introduced genuine novelty into the world. Within this view God still knows the future in that He knows what He plans; but His plans are often conditional, dependent upon the creation. This is certainly a conclusion consistent with Scripture. The conclusion appears to be superior to any view that starts from a thorough determinism in that it allows God to act in the world in a way consistent with the potentialities of the world as an autonomous creation completely dependent upon Him for its continued being. It appears to speak of the largeness of a God who is willing to take risks with His creation so that what is lost in power and knowledge by the gifts He has given may return as greatness of heart.

Furthermore, a question that has been waiting to be answered from the first may now be clearly answered in the affirmative. The activities and explanations of the scientist and the historian are bona fide. Their endeavors have at least the possibility of producing a genuine, although possibly not a complete, understanding.

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NEWS AND COMMENTS

BIOLOGY BOOK BATTLES

Controversy has arisen in several states over the use of a high-school biology textbook, *Biology: A Search for Order in Complexity*, prepared by the Creation Research Society (CRS) and published by Zondervan Publishing House in 1974.

In Texas there has been more publicity than action. The Dallas public school board voted 6 to 3 to adopt the text as a supplementary source book. Evolutionists and liberal clergymen threatened to take legal action in order to reverse the board's decision and prevent the teaching of creationism in the public schools. Because much publicity over the textbook adoption was generated by the news media, "Americans United for Separation of Church and State" arranged a formal panel debate on creation and evolution in order to present both sides of the question of origins to the public. The presentation took place at the Dallas Public Library and was televised on February 24, 1977.

In Indiana the battle has been much more involved. After the state's textbook commission included the CRS book among its list of state-approved texts in 1975 (and reaffirmed the decision in March 1977), the West Clark and South Ripley school districts adopted it as their sole text, while the remaining five districts used it in conjunction with other textbooks.

In Clark County the parents of two students appealed to the Indiana Civil Liberties Union (ICLU). They argued that the text promoted the Biblical theory of creation in such statements as: "a primary purpose of science should be to learn about God's handiwork," "there is no way to support the doctrine of evolution," and "the most reasonable explanation for the actual facts of biology as they are known scientifically is that of biblical creationism." While defenders of the text such as West Clark School District Superintendent Herman Miller insisted that it presented more than just the Biblical account of origins, critics labeled it as "antiscience" and an attempt to promote fundamentalist religious ideas in the public-school classrooms.

After studying the book, its teacher's manual, and publisher's correspondence, Marion County Superior Court Judge Michael T. Dugan announced in Indianapolis, on April 14, 1977, that the use of the CRS text, which he considered to be clearly one-sided, violated the state statutes, the Indiana constitution, and the U.S. constitutional provisions of separation of church and state. He then ordered the textbook commission to remove

the textbook from the state-approved list. In his ruling, Judge Dugan stated: "Throughout the text, while both viewpoints are mentioned, Biblical creationism is consistently presented as the only correct 'scientific' view. Two entire chapters, in fact, are devoted to lengthy discussions of the fallacies and weaknesses of the evolution viewpoint. On the other hand, there are no chapters or passages in the text which deal critically with Biblical creationism."

Judge Dugan declined to comment as to the validity of either evolution or creationism, saying that the "question is whether a text obviously designed to present only the view of Biblical creationism in a favorable light is constitutionally acceptable in the public schools of Indiana. Two hundred years of constitutional government demand that the answer be no." He added: "The prospect of biology teachers and students alike forced to answer and respond to continued demand for correct fundamentalist Christian doctrines has no place in the public schools."

While controversies have arisen over the CRS textbook in the states of California, Arkansas, Tennessee, and Texas, the Indiana case was the first to reach the courts. ICLU attorney Irving L. Fink predicted that Judge Dugan's decision would have "tremendous impact around the country" and commented that the commission "didn't have the guts to change their position" even though their original adoption of the CRS text had been a mistake.

Superintendent Miller remarked that the West Clark School System would continue to use the banned text, because "as far as we're concerned, it is a legal book until the textbook commission tells us it is not. If we have to change, it's going to cost a lot of money." State Superintendent of Schools Harold M. Negley, who is also chairman of the commission, stated that a decision on an appeal of Dugan's ruling would be made after the commission and state's, attorney general examined the ruling and that the CRS book would remain in use at least until the commission's next meeting which would be scheduled later.

Legal actions and court decisions are not the only means by which evolutionists and other opponents of the teaching of creationism continue to battle. Apparently believing the "scientific community" to be threatened by the teaching of creation in the public-school classrooms, the American Humanist Association (AHA), led by its president, Bette Chambers, issued an attack in the January/February 1977 issue of *The Humanist*, a journal sponsored by the AHA and the American Ethical Union. (Effective with the November/December 1977 issue, the latter group will no longer sponsor the journal.)

The issue opened with a statement affirming evolution as a principle of science. Signed by over 160 prominent scientists, educators and religious

leaders, the statement declared that evolution is firmly established in the view of the modern scientific community and is "the only view that should be expounded in public-school courses on science, which are distinct from those on religion."

The statement was sent to the major school districts in the United States with a plea for "all local school boards, manufacturers of textbooks and teaching materials, elementary and secondary teachers of biological science, concerned citizens, and educational agencies" to oppose measures before state legislatures that require equal treatment and emphasis of creation in the science classes and texts of public schools. The statement also urged supporters of evolution to reject the concept that evolution is a tenet of the religion of secular humanism and to support those who present the matter of evolution fairly in the classrooms.

The Humanist then proceeded to print articles supporting the statement. Preston Cloud, a biogeologist with the U.S. Geological Survey, led off the attack by calling scientific creationism "the new inquisition." He warned that "although the creationists may be irrational, they are not to be dismissed as a lunatic fringe that can best be treated by being ignored. In California, which accounts for about 10 percent of the public-school enrollment and thus exerts great leverage on textbook publishers, they have proven themselves to be skillful tacticians, good organizers, and uncompromising adversaries." Although Cloud's article was intended to produce evidence for evolution, most of his remarks were confined to derogatory statements about the damage that creationism was doing to the progress of science.

William V. Mayer, director of Biological Sciences Curriculum Study, gave a history of evolutionary theory, attempting to establish the concept's nobility by virtue of its longevity. Thus according to him, even the earliest written records of mankind anticipated the elements of the modern theory of evolution. Charles Darwin was praised for developing concepts of selection that explained the "how" of the evolutionary process. Mayer then lauded the increasing wealth of data supporting evolution and predicted that the future would show even more evidence until the anti-evolutionists would "occupy the same place as do members of the Flat Earth Society in these days of interplanetary exploration." He also stated that "evolution has become so pervasive that to inveigh against it is similar to King Canute requesting the retreat of the tide."

Bette Chambers summarized the section by explaining reasons for the statement on evolution: "Since the public is led to believe, thanks to creationist clamor so characteristic of this century, that an open choice between these two alternatives exists within the science itself, it becomes imperative to state that this view is rubbish, lest science education in America become the laughing stock of the civilized world."

When *Science News* included a brief news item on the evolution statement, reactions as indicated by the "letters" column during the following weeks ranged the extremes from praise to criticism. Some also attempted to find common ground between creation and evolution by suggesting forms of theistic evolution. In the May/June 1977 issue of *The Humanist*, eight of the twelve letters criticized the AHA for dogmatic, narrow-minded intolerance of other views. If the letters could be used as indicators of public opinion, then the myth of the unified scientific community is disproved, and it is not correct to say that all evolutionists are opposed to the teaching of creation theory in science classes. It is doubtful that the statement affirming evolution as a principle of science served to change anyone's views, and it will not intimidate creationists into ceasing their efforts to have creation presented in the public-school classrooms as an alternative theory to evolution.

Katherine Ching

LITERATURE REVIEWS

Readers are invited to submit reviews of current literature relating to origins. Mailing address: ORIGINS, Geoscience Research Institute, 11060 Campus St., Loma Linda, California 92350 USA. The Institute does not distribute the publications reviewed; please contact the publisher directly.

A REFERENCE ON CREATIONISM

SCIENTIFIC CREATIONISM (Public School Edition). Henry M. Morris, editor. San Diego, CA: Creation-Life Publishers. 230 p.

Reviewed by R.H. Brown, Director
Geoscience Research Institute

The recent interest in achieving a fair and appropriately balanced treatment of origins in the public schools has brought a realization of the inadequacy of educational material that presents creationism from a scientific viewpoint. *Scientific Creationism* is the result of an effort by a team of 23 scientists, theologians and teachers to provide a reference book suitable for presentation of creationism on a non-sectarian basis in the public schools. Any effort to produce such a book is to be commended. Knowledge in the natural sciences has progressed to a point at which it should be possible to prepare a treatment that places the creation approach to origins in a respectable and favorable position from a scientific viewpoint.

Scientific Creationism will undoubtedly serve in the accomplishment of much good, but unfortunately it does not measure up to expectations. The authors have not succeeded in presenting creation concepts on a purely philosophical and scientific basis. Viewpoints unique to one major religious document (the Bible) and characteristic of one particular school of Christian thought (ultra-conservative evangelical theology) are taken for granted as essential features of a scientific creationism suitable for presentation in public schools. For example, much effort has been exerted to "prove" that scientific evidence supports an age of only a few thousand years for the material universe. Among devout, Bible-believing Christians who are conversant with the scientific data related to this view, there are few (relatively speaking) who would suggest that it has any basis of origin other than in the testimony of Moses.

Without the Bible and any religious disposition whatsoever, one could logically (scientifically) propose that the material universe and the life it

supports were created by a superior intelligence. There is a rapidly increasing and impressive body of scientific evidence that may be conformed more readily to this view than to the view that undirected, random behavior of inanimate elementary matter, given sufficient time, is adequate to account for the present complexity of the universe. But we are indebted to what may be described as religious sources for the concept that these features are of quantifiably recent and coincident origin.

One may wish for the assurance that his particular views are "proven by science," particularly if he experiences a need for affirmation of these views in a hostile intellectual environment. Attempts to orient scientific data with a religious viewpoint in an intellectually satisfactory manner are a legitimate and necessary activity on the part of believers. But in any material intended for use in the public schools it is important to make a clear distinction between evaluation of scientific data from the viewpoints of diverse basic interpretive concepts, and efforts to fit such data into a particular religious viewpoint. The former has a justifiable place in science and philosophy courses; the latter only in a study of religious subculture groups (sociology) and theology.

Some of the discussion presented by Morris in support of a recent creation clearly indicates a recent origin for many of the present features of our planet's surface and its inhabitants. Other portions of this discussion may be expected to weaken efforts to defend the creation viewpoint among individuals who are conversant with the scientific data involved. Analysis of the numerous examples of inaccurate presentation of data and misunderstanding of the related scientific principles that such individuals may find in many sections of this book would extend beyond the normal limits of a book review. Three examples from one chapter may be given for illustration.

The statement on page 142 that "literally all of the so-called radiogenic isotopes of lead found in uranium-thorium systems anywhere can be accounted for by this process [neutron capture] alone" will dismay readers who are acquainted with the related evidence. In the model proposed by the authors this statement requires that the observed positive correlation between thorium 232 and lead 208 in uranium-thorium minerals be accounted for by localized exposure to fast neutrons proportional to the thorium concentration, and without contribution from in situ radioactive transformation of thorium to lead or from daughter-product lead incorporated with parent thorium in the formation of the mineral. This model is also contradicted by the observation that lead associated with uranium generally has a *lower* proportion of lead 208 and lead 207 to lead 206 than

does common lead. Furthermore, there is no evidence for a naturally occurring process that would produce as much as 1/10,000 the neutrons required by this model (see Cook, as cited by Morris, p 61-62). Consideration of the probability for neutron capture by a lead nucleus introduces an additional factor of magnitude of 10^{-24}, making the model all the less probable.

The assertions that the K-Ar method of radiometric dating "must be calibrated by uranium-lead dating" (p 145), and that the Rb-Sr method "must be calibrated against the uranium method" (p 148) are without support in theory or practice. While there are numerous and significant cases of agreement within experimental errors (concordance) between the results of applying these techniques to a rock sample, the complete independence of each with respect to the others is demonstrated by the disagreement (discordance) between them that is commonly encountered.

On page 162 highly questionable evidence for a change of less than one percent in the radioactive transformation rate of carbon 14 at concentrations many orders of magnitude greater than could be expected under natural circumstances is cited as proof "that C-14 decay rates actually could have varied in the past to an extent which would render invalid most radiocarbon 'ages'." (Most C-14 ages are not determined within an accuracy or a precision of one percent.)

The treatment in this book covers a broad range of topics, including space science, cosmology, geochemistry, thermodynamics, radiometric dating, geology, paleontology, molecular biology, genetics, anthropology and population growth. The discriminating reader can find much useful material on many of these topics, but to recommend the book to someone who is not equipped to evaluate its contents would be questionable.

The authors are to be commended for their efforts to meet a high priority need. It is unfortunate that the literature on the creation viewpoint was not more fully developed at the time their manuscripts were prepared.

GENERAL SCIENCE NOTES

CLASTIC DIKES

Ariel A. Roth
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The sediments that cover the surface of the earth are usually laid down in a horizontal or near-horizontal position and frequently remain that way. Occasionally within these layers are somewhat vertical cracks filled with different kinds of sediments. These vertical foreign bodies of sediments penetrating the horizontal sedimentary layers are called clastic dikes (Figure 1). The size of the dikes can vary in thickness from a few centimeters to hundreds of meters; their height is usually several times greater than their width. Often the sediments in the dikes come from other sediments found below the intruded layers. The process of formation is analogous to wet sand oozing up between one's toes, only on a larger scale.

Clastic dikes pose time constraints for the two deposits forming them, because the lower layer which furnishes the sediment for the dike must have remained uncemented while the upper intruded layers were laid down. Subsequent pressure forced the still-soft sediments below into the crack in the firmer upper deposits. In the context of the long ages assumed for geologic time, the intruded sediments (above) and the intruding ones (below) are considered to have formed at approximately the same time. Such units are designated as penecontemporaneous (i.e., formed before consolidation).

Clastic dikes are a peculiar but not unusual occurrence (Shrock 1948, p 212-221; Newsom 1903). Found throughout the geologic column, large numbers of them have been described in the Cretaceous and Tertiary. About 500 have been noted in central and northern California (Peterson 1968, Smyers & Peterson 1971). Ten thousand are reported in Japan from Permian to Pleistocene with the majority being in the Miocene (Hayashi 1966).

One series of dikes of special interest to one seeking to determine the age of sediments in the earth is found in the Front Range of Colorado north of Pikes Peak (Gross 1894, Roy 1946, Vitanage 1954, Harms 1965). In this case, sand from the Cambrian Sawatch sandstone has intruded into the Precambrian Pikes Peak granite during the Laramide Orogeny.

FIGURE 1. Portion of a clastic dike located in the Panoche Hills on the west edge of California's Great Valley. The dike which consists of hard sandstone is the nearly vertical, lighter-colored rock unit found in the lower central part of the picture. It is about 1 meter wide. On either side and above lies the softer Late Cretaceous Moreno Shale largely covered by a thin layer of vegetation.

This orogeny is the main uplift forming the Rocky Mountains which occurred relatively late in geologic time. There is disagreement as to whether the intrusions forming these dikes are from below or from above; in this case the time discrepancy is so great that this point makes little difference. The sandstone dikes contain fragments from the Permian-Pennsylvanian Fountain Formation, indicating that at least this formation was present at the time of intrusion. On a geologic time scale this represents a period of at least 250 million years during which the Sawatch sandstone remained uncemented. This seems especially unusual since just above the Sawatch are several carbonate layers that could provide an abundant source of cement for the Sawatch. If, as field evidence indicates, intrusion took place during the Laramide Orogeny, the Sawatch sandstone would have

had to remain uncemented for more than 400 million years. On the other hand, if, as expected, dikes are formed at approximately the same time as their host rock, or at least the cracking of the host rock during the Laramide Orogeny in the Pikes Peak granite case, then there must not be much time difference between the Cambrian and the Laramide Orogeny which supposedly occurred more than 400 million years later!

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EDITORIAL

IMPLICATIONS OF THE SPREAD OF DARWINISM

"Modern critics have often asked themselves how it is that a hypothesis like Darwin's, based on such weak foundations, could all at once win over to its side the greater part of contemporary scientific opinion." This quotation from the pen of the historian Erik Nordenskiöld (1928, p 477), in his treatise on the history of biology, presents an enigma that has more than passing interest for one seeking to find a basis for decisions regarding origins.

Evolution is considered to be one of the major intellectual achievements of the 19th century, and its widespread acceptance in spite of the paucity of supporting evidence presents a question of major import. Why does one hypothesis survive over another?

When Darwinism triumphed there was essentially no understanding of genetic mechanisms, a key concept in the operation of the theory. Darwin proposed the pangenesis theory which suggested that minute particles called "gemmules" from all parts of the body travel to other parts including the reproductive cells, thus causing offspring to resemble parents. These ideas have been rejected long ago.

The idea of natural selection as the basic mechanism for the evolution of all life was questioned then as it is now (see *Origins* 4:4-10). The lack of tangible support for Darwin's views was a problem. Young (1971) states: "Darwin's task was to explain *away* the *lack* of evidence while repeatedly stressing the greater plausibility of his theory over that of special creation."

Another problem was the large gap between the small variations Darwin observed and the origin of significantly different kinds of organisms. Yet the theory required that all kinds of organisms be produced from simple to complex, and this was not observed. This has been a source of dissatisfaction with the theory from its beginning. Grene (1959) commenting on Darwin's *Origin of Species* states: "It simply is not about the origin of species, let alone of the great orders and classes and phyla, at all. Its argument moves in a different direction altogether, in the direction of minute specialised adaptations."

Perhaps the most difficult problem Darwin faced was the nature of the fossil record where discontinuity (gaps) as expected in a creation model, instead of continuity (no gaps) as expected in an evolution model, seemed to prevail. Darwin stated in the *Origin of Species* (1860, p 321): "Those who believe that the geological record is in any degree perfect, will undoubtedly at once reject the theory." Darwin then undertook to show that the discontinuity between fossils resulted from the imperfection of the geologic record instead of this being a problem with the theory of

evolution. However, the absence of evolutionary intermediates was an argument from silence which could scarcely convince the skeptic.

One of the strongest arguments leveled against Darwin's idea was the question of how random variation could result in producing highly integrated structures such as the eye. Apparently this question troubled Darwin, for he wrote (1888, vol. 2, p 296) to his supporter, the American botanist Asa Gray:

> *...I remember well the time when the thought of the eye made me cold all over, but I have got over this stage of 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!*

During Darwin's last year of life, the Duke of Argyll had a conversation with him in which he asked if the wonderful contrivances described in Darwin's books on earthworms and orchids were not the "effect and the expression of mind." The Duke goes on to state:

> *I shall never forget Mr. Darwin's answer. He looked at me very hard and said, 'Well, that often comes over me with overwhelming force; but at other times,' and he shook his head vaguely, adding, 'it seems to go away.'* (Darwin, 1887, vol. 1, p 316n).

There was also some question regarding Darwin's scientific methodology. The rigor that had produced phenomenal success in the physical sciences at that time appeared to be lacking. His friendly mentor, the noted geologist Adam Sedgwick, in a letter to Darwin (Darwin, 1888, vol. 2, p 248-249) stated:

> *I have read your book with more pain than pleasure. Parts of it I admired greatly, parts I laughed at till my sides were almost sore; other parts I read with absolute sorrow, because I think them utterly false and grievously mischievous. You have deserted — after a start in that tram-road of all solid physical truth — the true method of induction, and started us in machinery as wild, I think, as Bishop Wilkins's locomotive that was to sail with us to the moon. Many of your wide conclusions are based upon assumptions which can neither be proved nor disproved, why then express them in the language and arrangement of philosophical induction?*

This brief survey of the controversial milieu in which Darwinism rapidly won over most of scientific opinion raises the question of why it triumphed. This editorial does not propose to give an answer to this complex issue, but it can be definitely stated that victory was not on the basis of overwhelming scientific evidence. That it occurred is a matter of great import. The historian Nordenskiöld (1928, p 477) further emphasizes this: "The factors governing the victory of Darwinism thus represent a problem of the greatest importance, not only in the history of biology, but also in that of culture in general."

The triumph of Darwinism seems to indicate that the intellectual matrix in which one finds himself may dictate one's opinion as to what is true more than objective knowledge does. This should be a matter of serious concern for science. It is part of the reason why Thomas Kuhn (1970, p 151) in his book *The Structure of Scientific Revolutions* refers to a change of paradigm as a "conversion experience." One wonders how many modern scientific concepts have a weak objective basis. If science is to efficiently arrive at truth, as it should strive to do, it must studiously avoid selecting paradigms which do not have a sound empirical foundation.

Ariel A. Roth

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REACTIONS

Readers are invited to submit their reactions to the articles in our journal. Please address contributions to: ORIGINS, Geoscience Research Institute, 11060 Campus St., Loma Linda, California 92350 USA.

Re: Kootsey: Can the Christian Afford Scientific Research? (ORIGINS 3:97-100)

I very much enjoyed the article by Mailen Kootsey. He says some things which have needed to be said in the conservative Christian community for a long time. I hope that the leadership of this community will recognize the validity of his viewpoint and seek to assist Christian scholars in a more active research program in a variety of areas.

Personally, I feel there is another important reason why the Christian *must* afford scientific research. In educational programs for the next generation of young Christians in theology, the arts and sciences and the derived professions, Christian teachers must use the knowledge produced by the efforts of other scholars both Christian and non-Christian. Surely we have an obligation, even a moral obligation, to contribute to this body of knowledge by sound research and scholarship. Otherwise we are parasites drawing on resources to which we have made no contribution.

Granted that our priorities may be different from those of secular society, I am still forced to the conclusion that Christians must conduct scientific and other scholarly research and that Christian educational institutions and their supporting organizations must allocate a significant share of their resources to such activity. Obviously, there will be an emphasis on certain areas and aspects in such a research effort although no area should be automatically excluded. We might be surprised by the impact of such activity as a form of Christian witness to members of the intellectual community, other leaders in thought and ultimately the world at large.

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RE: Stidd: Reactions (ORIGINS 4:12-15)

Dr. Stidd has summarized one way of interpreting homologies, but there is another equally valid way of looking at them.

One of his main objections is that if the major groups of animals were created, there should be differences between natural homologies (arising through natural selection) and supernatural homologies (similarities designed and created by God), and thus we should be able to identify which homologous features were created and which ones have developed through natural processes.

Since an animal's characteristics are controlled by its genes, a certain set of genes will produce a certain type of animal, irrespective of how those genes

were selected — selective breeding by a geneticist, natural selection, or deliberate choice by a Designer. Consequently if we are going to find detectable differences between supernatural homologies and natural or evolved homologies, we would need to predict that the complement of genes chosen for each original animal by the Creator would be different, in some very fundamental way, from the complements of genes that would be subsequently favored by natural selection. But if the Creator who made the original animal kinds with their individual genetic makeup was the same Creator who designed the genetic mechanism that would allow them to diverge into new species and adapt to changing conditions, we would expect to find a unity throughout the genetic systems of all living things. If that is the case, why would there be any basic differences between "natural homologies" and "supernatural homologies"? In the process of adaptation to a new environment we would expect natural selection to favor the combination of genes that will produce the best adapted animal for that environment. If the Creator had originally designed the animal for that lifestyle in that environment, would we expect Him to have chosen a less suitable set of genes? If an intelligent, logical thinking God who knows everything about biological systems designed animal genetic systems with the potential to adapt to new circumstances that may arise, and also used that same genetic code to design the first animals to be well adapted to their first environment, I see no basic reason for believing that there would be detectable differences between "supernatural homologies" and "natural homologies."

One possible exception to the above conclusion is that perhaps there would be essentially quantitative differences in the genetic gap between created types as compared to subsequently developed variations within created types. For example the differences between fish and mammals (which the creationist will consider to be different created groups) are far greater than the differences between two similar species of *Peromyscus*, or white-footed mice (probably new species that developed within a created kind). At intermediate taxonomic levels — orders, families, and genera — we would expect to find differences that are intermediate in magnitude. The result is somewhat of a continuum, with the smallest degree of taxonomic divergence at the subspecies level and the greatest divergence at the kingdom level. One could then ask whether there is one taxonomic level (the genus level, e.g.) that shows, on the average, a greater-than-expected amount of change in taxonomic divergences. For instance, if extensive study demonstrated that the differences between genera are generally more distinct and consistent than might be expected, then one could theorize that the genus was, *on the average*, the limit of the created kind. However, there also might be other equally logical explanations for that data. And if there is no unexpected jump in taxonomic divergence at any taxonomic level, there may be several reasonable theories to explain that, including the possibility that the amount of genetic difference between created kinds was sufficiently small and variable to make it very difficult for us to determine what the created kinds were. If one assumes that all organisms evolved, then homologies may be useful to indicate the most likely evolutionary pathways; and if one assumes creation, then homologies may or may not provide information that can help to indicate

the most likely limits of the created kinds. However, if we ask the more fundamental question, "Is macroevolution true, or is creation true?" — homologies are no help, because they can be logically explained by either view.

The letter suggests that "if the creationist paleontologist finds that he cannot distinguish between natural and supernatural homologies and natural and supernatural taxa, perhaps this suggests that he should examine his basic premises." Then he lists the following possible sources of error:

1. his criteria for delimiting natural and supernatural homologies are faulty,
2. he has misunderstood the thought patterns of the Designer,
3. the evolutionary position is correct and variation among organisms cannot be divided into natural and created categories.

To be complete, the list needs at least one more alternative:

4. The original created organisms and the genetic mechanism for future adaptations were all part of an integrated design by the same Designer, and thus it may not be possible to discover any differences between "natural" and "supernatural" homologies.

Criticism is made of the analogy between the "evolutionary trees" for animals and wheeled vehicles, and the conclusion is drawn that "the contention that the same principles of comparison are applicable to vehicles and organisms is like comparing apples with bolts; apples can produce apples — more bolts can be produced only by man. Only if one has evidence that man can produce apples is the logic satisfied." These comments illustrate the well-known concept that all analogies break down if they are carried too far and applied in ways that were not intended.

Since none of us has lived all through earth history to observe directly what biological changes have occurred since the beginning, we only have access to indirect, circumstantial evidence. We can only look at homologies and other types of indirect evidence in living and fossil animals and use that data to hypothesize how much change has occurred and which animals descended from which others. However, there is generally more than one reasonable explanation for indirect evidence like that. My analogy between evolutionary trees for animals and for vehicles illustrates only one point — namely, that because animals can be arranged in a sequence from simple to complex, based on homologies, is not *in itself* evidence that they evolved from a common, simple ancestor. Additional, more direct, evidence would be needed to answer that question. If the analogy is applied in other ways, naturally it falls apart.

If one *assumes* evolution from simple to complex, homologies can be useful in tracing the most likely lines of descent. If one is trying to determine whether evolution or creation is more likely to be correct, homologies do not help in making that decision.

The letter raises another important issue, and that is concerning the nature of evidence, especially as it relates to studies of historical processes such as evolution. The letter's reconstruction of a possible dispute between a creationist and an evolutionist indicates that the latter "believes he can account for observed

differences and similarities on a natural basis and sees no compelling reasons why supernatural agencies need be invoked." However, the fact that he doesn't see reasons for invoking supernatural agencies is quite irrelevant to the fundamental issues in the dispute, for he also cannot produce compelling evidence *against* the possibility of supernatural involvement.

The letter points out that a problem with a creationist view is that it cannot be refuted or proven false by any data. In other words it cannot be scientifically tested; "it rests on an assumption not amenable to empirical analysis." A balanced discussion of this issue must also recognize that large areas of the evolution theory also rest on assumptions not amenable to empirical analysis and cannot be scientifically tested. Creationists are not the only ones who recognize that problem. For instance N.I. Platnick (1977. Review of Evolution and the diversity of life. Systematic Zoology 26:224-228), an evolutionist, states that "both kinds of explanations [creation and natural selection] fall into the category of those 'that could neither be proven nor refuted'." L.C.Birch and P.R. Ehrlich (1967. Evolutionary history and population biology. Nature 214:349-352), also evolutionists, discuss the problem of the non-testability of evolutionary hypotheses and how it affects their research fields. They state that to "attempt to investigate ecology and taxonomy through a series of inferences about the past is to base these sciences on non-falsifiable hypotheses." This problem of the non-testability of theories about the past also applies in other fields besides ecology.

The letter indicates that an evolutionist will reject supernatural agencies because "he believes that he can account for observed differences and similarities on a natural basis and sees no compelling reasons why supernatural agencies need be invoked." On the other hand Platnick (op.cit.) concludes that this kind of reliance on logical, "good enough" explanations even though they "are (at least practically) untestable...makes of evolutionary biologists spinners of tales, bedtime storytellers, instead of empirical investigators."

The view is presented in the letter that "if there is no difference [between natural and supernatural homologies], the creationist interpretation appears to be an ad hoc argument designed to harmonize science and Scripture." However, one can also propose that the hypothesized ability of natural selection to produce unlimited change and increased complexity is an ad hoc argument designed to eliminate the Designer from the system. Which explanation a person chooses is largely the result of his philosophy and his preconceptions. Only when we all (creationists and evolutionists) recognize how much our conclusions are affected by our preconceptions and our philosophical choices and recognize the nature of the assumptions that we make (consciously or unconsciously) will we be able to fruitfully discuss the fundamental issues.

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ARTICLES

RADIOMETRIC AGE AND THE TRADITIONAL HEBREW-CHRISTIAN VIEW OF TIME

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WHAT THIS ARTICLE IS ABOUT

Traditional Biblical interpretations indicate a period of about 6000 years since creation week. Other interpretations based on radiometric dating suggest that life has been on earth over half a million times longer. This article analyzes some of the scientific data related to radiometric age dating. Of special interest are the facts that: 1) Inconsistencies exist in several areas, 2) the practice of dating an organism or geologic event by dating the rocks associated with it may be unsound since the rocks may be older than the organism or event dated, 3) some radiometric dates are dependent on the size of particles measured, 4) some sequential series of radiometric dates showing increase in age with depth in the earth are due to the nature of the process of ejection from volcanoes and not an increase in age.

The marginal entries in most of the older English Bibles allow less than 6000 years since the Creation described in the first chapters of Genesis. Outside the Hebrew-Christian tradition our world generally has been considered to be of vast antiquity.

The Babylonian scholar Berossus (3rd century BC) placed Creation at 2,148,323 BC, the first of the "10 ancient kings" (Adam in Gen 5?) at 468,323 BC, and the Flood at 36,323 B.C.[1] The Greek philosopher Plato (4th century BC) considered that the Flood occurred about 200 million years ago.[2] Apollonius of Egypt (2nd century BC) proposed a mere 155,625 years for the age of the world.[3] The Hindu classics written in the middle of the first millennium after Christ describe the history of the world in terms of endlessly repeating grand cycles of 4.32 billion years duration, each containing one thousand subcycles 4.32 million years in length.[4] Chinese scholars as early as the 3rd century BC thought of world history in terms of endlessly repeating cycles and subcycles. I-Hsing (8th century AD) placed the beginning of the latest "Grand Period" or cycle at 96,962,464 BC.[5]

Within the last 100 years the dominance in European civilization of the traditional Hebrew-Christian viewpoint concerning the age of our world has been replaced by the "scientific" view that planet Earth has been in existence for about 4.56 billion years and has supported complex forms

of life over the last 600 million years. The "scientific" view is presumed generally to be firmly based on unquestionable radiometric data.

The "scientific" view of Earth's age was developed in preliminary form many decades before the discovery of radioactivity. In 1778 Comte de Buffon cautiously broke with Hebrew-Christian tradition in proposing that planet Earth had been in existence more than 75,000 years.[6] In a lecture delivered to the Royal Society of Edinburgh in 1785, and in a book published ten years later, James Hutton placed the origin of Earth at a vastly remote and indefinite time.[7] In this lecture he set the horizons for geologic time with the classic expression "...no vestige of a beginning, — no prospect of an end." Immanual Kant placed the original creation "a series of millions of years and centuries" into the past.[8] Erasmus Darwin, whose grandson wrote *The Origin of Species*, actively promoted the concept of evolutionary development of organisms over "millions of ages,"[9] and the evolutionist Jean Baptist de Lamarck, at the beginning of the 19th century spoke of time in "millions of years."[10]

During the development of geological science in the early 19th century the span of geologic time was placed in the three million to 1.6 billion year range.[11] These early speculations were based on estimates of sedimentation rates and the total sediment presumed to have accumulated during each of the various divisions of geologic time. The demands of evolution theory were strongly coercive toward estimates that supported the longest time span that could be contrived reasonably. Evolution theorists such as Charles Darwin and T.H. Huxley were uncomfortable with the limited amount of time provided by these early estimates.[12]

The 20th century development of radiometric dating produced a geologic time scale that appears to be firmly founded on sound physical science principles and precise measurements. By extending geologic time to over four billion years radiometric dating initially appeared to provide adequate time for a dust-to-man evolutionary development. But the understanding of biochemistry, molecular biology and genetics that has developed within the last quarter century has brought a realization that *any phase* of the presumed process of organic evolution (formation of the necessary biochemicals, development of primitive living cells, evolution of primitive cells into modern organisms) is unreasonable within the entire span of the radiometric time scale. Thus even if one considers the current popular interpretations of radiometric data to be correct, he must have faith that organic evolution has progressed from cell to man somehow[13] despite insufficient time provided by radiometric dating for the age of the earth.

Individuals who are not acquainted with the research reports in the scientific literature are seldom aware that a high degree of interpretation and selection among available data has been necessary in the development of a radiometrically calibrated geologic time scale. Only data that fit into generally accepted paleontological and geological theory have been utilized in this development.[14]

The construction of a radiometric geologic time scale is based on the assumption that mineral samples may be obtained which contain only results of radioactive transformations that have occurred since the mineral was placed in its present surroundings. Another way to state this assumption is to say that radioactive "clocks" were "set to zero" (the accumulated results of all previous radioactive transformation were removed) when the mineral was either formed or deposited at its present location. According to this assumption the remains of an organism are at least as old as the radiometric age of the mineral that has replaced these remains, of a geologic formation that contains them, or of a geologic formation that overlies or penetrates the formation that contains them. Because it readily led to age interpretations that were consistent with the popular philosophical framework this assumption has not been analyzed as critically as it should have been.

It is not reasonable to expect that naturally occurring physical and chemical processes would isolate radioactive elements and compounds or their stable end-products in absolute chemical purity. Igneous, erosion or solution processes should be expected to transport at least a portion of the daughter products that were initially associated with parent radioactive material at the site of origin. The various radiometric age characteristics at the relocated site should then be expected to reflect to some degree the original radiometric age characteristics, the nature of the transfer process, exposure to heat and fluid circulation since the transfer, and the time since transfer. Only in situations that provide radiometric data for several diverse minerals and radioactive systems can one expect to separate any of these factors from the others.

Reference to significant disagreement between radiometric age data and conventional geologic age classification appears frequently in the professional literature. A recent paper that has received widespread attention lists 22 examples of Tertiary age (65 million years or less on the conventional geologic time table) that have rubidium-strontiurn (Rb-Sr) ages[15] ranging between 70 and 3340 million years.[16] Five continental areas are represented in this collection (Table 1). Each of these examples can be explained best on the basis of varying degrees of inheritance of source area radiometric

TABLE 1

Rubidium-Strontium radiometric ages for selected Tertiary volcanic material. Data taken from Table 1, reference 16.

Location	Association	Apparent Age (million years)
USA	Absaroka volcanic field; andesites	3340 ± 1540
USA	Western Grand Canyon; hawaiites	1300 ± 290
USA	Western Grand Canyon; alkali basalt series	1100 ± 240
USA	Colorado Plateau; basalts	960 ± 240
USA	Snake River plain; King Hill basalts	940 ± 210
Spain	Jumilla, alkalic complex; jumillites	780 ± 390
USA	Snake River plain; Craters of the Moon basalts	620 ± 60
USA	Absaroka volcanic field; shoshonites	470 ± 50
Peru	Arequipa volcanics; andesites, dacites	440 ± 70
Uganda	Napak alkalic complex; nephelinites, ijolites	380 ± 340
Peru	Barroso volcanics; andesites, dacites	310 ± 50
USA	Columbia River group; basalts, andesites, dacites	290 ± 80
USA	Basin and Range; basalts	200 ± 70
USA	Northwest Great Basin; basalts, andesites	190 ± 80
USA	Navajo alkalic province; trachybasalts, lamprophyres	170 ± 110
USA	Leucite Hills; lamproites, orendites	150 ± 80
New Zealand	East arc, North Island; basalts, andesites	110 ± 20
USA	Cascades, Glacier Peak; basalt, andesites	110 ± 90
USA	Cascades, Mt. Lassen; basalts, andesites, dacites	100 ± 50
Uganda	Budeda alkalic complex; ijolite series	80 ± 50
USA	Bearpaw Mountains alkalic complex; syenites, etc.	80 ± 40
Uganda	Torror alkalic complex; phonolites, nephelinites, etc.	70 ± 5

age characteristics for material which has been transported by plutonic or volcanic processes.

Recently deposited sediment on the floor of Ross Sea, Antarctica, has been found to have a 250 million year Rb-Sr age. The two major source areas for this sediment are the Transantarctic Mountains that have a radiometric age between 450 and 475 million years and West Antarctica for which the radiometric age is in the 75-175 million year range. The Ross Sea sediments are easily seen to have radiometric age characteristics that reflect a blend of the radiometric age characteristics of the source areas. Evidence that rubidium is incorporated into these sediments directly from sea water, with resultant lowering of the Rb-Sr age characteristics, adds to the difficulty of interpreting the radiometric age data in terms of relative contribution from the source areas, as well as with respect to time of transport.[17]

An explanation for the agreement between potassium-argon (K-Ar) age[18] and presumed geologic time can be found for at least some samples

in the observation that finer-sized components of a mineral formation may have a younger K-Ar age than larger-sized components, with the average K-Ar age of all components fortuitously in agreement with the presumed geologic age.[19] The higher surface-to-volume ratio of the smaller particles evidently favors a higher percentage of argon loss than from the larger particles, with the consequence that the larger particles retain a K-Ar age closer to that of the original source area.

An oil well in southwestern Louisiana that was drilled into formations which have a conventional geologic age in the 5-25 million year range (Miocene) furnished from the 5190 foot level shale that has a K-Ar age of 164 million years (m.y.) for particles less than ½ micron in diameter, 312 m.y. for ½-2 micron particles, 358 m.y. for 2-10 micron particles, and 372 m.y. for particles greater than 10 microns in diameter. The corresponding whole-rock K-Ar is 254 m.y. The radiometric ages for the sediments in which this well was drilled reflect the radiometric age characteristics of the source areas drained by the Missouri and Ohio river systems, not the time of placement.[20]

The validity of the geologic time scale is brought into question also by radiohalos, which are regions of radiation damage surrounding a microscopic inclusion of radioactive material. Coalified wood from Triassic and Jurassic sediments (225-135 m.y. conventional geologic age) has been found that contains radiohalos.[22] If one assumes an *in situ* decay in the inclusion centers of these halos, the lead-206/uranium-238 ratios present may be expressed in terms of uranium-lead ages[21] ranging between 236 thousand and 2.9 million years. There is no presently available experimental evidence which could exclude the possibility that essentially all the lead-206 in these halo centers was introduced (either directly or as parent polonium-210 or lead-210) together with the uranium, and thus did not accumulate from uranium since the inclusion was formed. There is evidence that the lead isotope ratios in these inclusions are related to the source area(s) from which the uranium was transported during the production of uranium-rich sediments in which coalified wood radiohalos are found, hence invalidating a real-time interpretation of the calculated ages given above.

The original radiometric age characteristics of source material can reflect the primordial characteristics of this material, radioactive transformation since primordial creation, and also exposure to heat, chemical activity and nuclear radiation prior to relocation. Confidence that for many available mineral samples the radioactive transformation effects can be isolated from these other factors is the basis on which a 4.56 billion year solidification age[23] has been established for the Solar System. Individuals

whose convictions concerning the interpretation of inspired testimony do not allow so great an age for inorganic material may classify the radiometric features from which this conclusion is derived as primordial characteristics that were introduced in a relatively recent creation.[24]

The popular concept that radiometric ages of geologic formations relate directly to their real-time age obtains much support from the observation that volcanic sequences, and volcanic-derived sedimentary sequences, usually exhibit a pattern of increasing radiometric age with depth. It is obvious that the upper material in a given undisturbed sequence was emplaced later than the underlying material. But the radiometric age differences between them does not necessarily represent the real-time emplacement interval. It has been established that the radiometric age profile of a volcanic sequence may be the consequence of: 1) chemical and isotope zonation in the magma chamber that furnished volcanic material, 2) circumstances that were progressively more favorable to resetting a particular radiometric clock (degassing of radiogenic argon, e.g.) as eruptions proceeded, and 3) crustal material incorporated by the magma as it moved upward.[25] There is evidence that fission tracks in crustal material may survive transport by volcanic activity;[25a] however, this is not the case with fission tracks in volcanic glass formed at the time of eruption.

In accord with these considerations the lowest material in a volcanic sequence represents the upper portion of the associated magma chamber and may have erupted in a more viscous, lower temperature state than did material that erupted later and is placed higher up in the sequence. Crustal material that was broken loose and carried along with the first magma that reached the surface could have experienced less annealing (erasure) of previously developed fission tracks than crustal material that was incorporated during later stages of the eruption sequence. Gaseous and other lighter components would likely be enriched in the upper portion of a magma chamber as a result of gravitational differentiation. Thus there are two factors that could contribute to a diminishing content of radiogenic argon as an eruption sequence proceeds — lower argon content of the lower portion of the magma chamber and increased degassing of the material that reached the surface at a higher temperature in the latter stages of the eruption sequence.

The book of Genesis references two episodes of crustal deformation and reorganization on planet Earth that are outside the range of prediction or explanation based on the normal day-by-day and year-by-year operation of geophysical processes — the original appearance of continents on the third day of Creation week, and the global destruction and reformation

described in chapters 6-8. The radiometric age characteristics of many rocks and mineral specimens that are now accessible would be expected to have been altered in each of these episodes. This alteration compounds the difficulties in making historically correct interpretations of radiometric age data.

Although a fully satisfactory explanation of all radiometric age data undoubtedly awaits more information than is presently available, it is the hope of the author that the information brought together and the suggestions made in this paper will assist in the development of a basic understanding that is consistent with both radiometric data and the chronological stipulations in the Bible.

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ARTICLES

THE IMPACT OF TEKTITES UPON AN ESTIMATED 700,000 YEAR HISTORY OF DEEP-SEA DEPOSITS

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WHAT THIS ARTICLE IS ABOUT

In this sequel to an article that appeared in Origins *3:85-96, the author pursues further the matter of conflicting dates obtained by various lines of evidence. The controversy presented in this article centers around small unique glassy objects called tektites, whose implacement appears to have occurred less than 6000 years ago according to carbon-14 dating, while other dating techniques indicate that the same kind of object when found in the ocean appears to have been placed over one hundred times earlier. Dating of ocean sediments containing these unique objects by a number of techniques which appear to give consistent results does not agree with the dating of comparable terrestrial sediments.*

Small, glassy objects in a variety of shapes have been found scattered all across the surface of Australia and southeast Asia. Known as tektites, they were first thought to have originated from outside the earth's atmosphere because of their aerodynamically sculptured surface. Though much of their surface patterns are strikingly similar to the surficial etchings on meteorites, yet the chemical composition of tektites is quite different. Having only a trace of nickel as opposed to meteorites, they are especially rich in silica (SiO_2) and rarely are composed of less than 70% SiO_2. Thus tektites are not the waste products from meteorite showers.

On the basis of data on samples collected by five Apollo missions to the moon it is generally conceded that tektites were not formed from a shower of molten material ("moon drops") propelled toward the earth as a result of meteorite impacts on the lunar surface. Rather, it is now believed that they have originated from gigantic meteorite impacts on the earth itself.[1] It appears that drops of molten material were projected into a low orbit and then re-entered the atmosphere at high speed, finally resting over a wide area known as a strewnfield. Artificial tektites of the same chemical composition as Australian tektites (australites) have been fashioned at air speeds of 17,000 m.p.h. in a wind tunnel at the Smithsonian Institute. To the untrained eye the end product is indistinguishable from natural

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tektites. Tektites from the Ivory Coast strewnfield have a chemical composition very similar to (if not identical with) the altered rocks of nearby Lake Bosumtwi, which has the main criteria of a meteorite impact site.[2] Recently a probable meteorite impact site, Elgygytgyn Crater, was identified from satellite photos and is now proposed as the source for australites.[3] The australite strewnfield is pie shaped and the apex points in the direction of Elgygytgyn in northeastern Siberia.

Australites have been dated concordantly at 700,000 years by two radiometric dating methods — fission track and potassium-argon (K-Ar). This represents a major challenge to conservative Christians wishing to hold to a short Biblical chronology. But these 700,000 year radiometric ages are now under question by the use of another radiometric method, radiocarbon dating. In the 1960's two independent teams of investigators[4,5] located australites *in situ* (see *Origins* 3:85-96). Since the publication of their findings, a third team working independently of the others has reached essentially the same conclusion: that the time of infall for the australites should be in terms of a few thousand years instead of the generally acknowledged radiometric age of 700,000 years.[6] These authors suggest an infall age of 6500 years based on a C^{14} date of 7300 years for wood fragments in the soil into which australites have fallen.

These conclusions place geologists and geochemists in a quandary. For those who have made first-hand field observations of australites, the evidence is in favor of a geologically young age, whereas those who work with them in the laboratory are convinced that the time when the tektites fell is the time of their last melting when the radiometric clock was re-set approximately 700,000 years ago.[7] According to one way of solving the dilemma, the older age represents their actual age of formation somewhere in space and the younger age represents their terrestrial age. This hypothesis has been ruled out by the fact that no cosmic ray tracks have been detected in tektites, as in meteorites; thus limiting their hypothetical journey in the solar system to less than 300 years.[8]

Another solution is to suggest that approximately 700,000 years ago the australites landed elsewhere than their present location and were subsequently washed into place as part of transported sediments a few thousand years ago. After reporting C^{14} ages of 5700 and 5350 years immediately adjacent to an australite, Gill notes that, if they were transported, neither the tektites nor the buckshot gravel which are always associated together at Port Campbell, Australia, "could have come far and both must have come gently because the edges are sharp on the australites, and the buckshot is not polished."[9] In a later publication Gill reaches the same conclusion: "The good preservation of the Port Campbell australites is against long residence in the soil, or long transport from one formation to another."[5]

More recently an author in commenting on Gill's conclusions notes that if the tektites were not transported, then the K-Ar age is under suspicion:

> *The Port Campbell australites as a geographical group are all astonishingly fresh and undegraded by terrestrial processes, as far as is known, and there seems little possibility that more than one shower is represented at Port Campbell. Hence, it is very difficult to accept Gill and Baker's conclusions, unless the K/Ar age date means something else than is commonly believed.*[10]

A 1976 study by a tektite expert confirms the fact that the dilemma has not yet been solved:

> *The papers of Gill and of Lovering et al. supply clear evidence that tektites are found on top of recent Australian soils whose ages, as given by carbon dating, are less than 20,000 years. The evidence is strong that they did not reach this position by reworking from older sediments at a higher elevation.¼ For example, a Czechoslovakian study shows that stream erosion will reduce glass objects of roughly tektitic character to about one-ninetieth of the original mass at a distance of 40 km downstream.*[11]

It is noted that in Lovering's study the nearest possible source for the tektites would be 15-20 km away. In commenting upon the 700,000 age for the flanges of tektites formed in their descent earthward, this expert concludes: "It appears that we must reject the very recent dates for the Australian tektites: something must be wrong, conceivably the dating of the hardpan."[12]

The Smithsonian study which was published in 1976 builds an even stronger case for the young age of australite infall, yet even it is unwilling to take that gargantuan leap and suggest that the fission-track and K-Ar ages may be in error. The report ends with these pointed observations:

> *No one who has seen the Port Campbell localities and examined the many perfectly preserved australites therefrom is likely to argue that these specimens are not being found essentially where they fell. The complete lack of solution etching, even on thin plates weighing as little as 0.03 gram, is a powerful argument against the australites having been subjected to terrestrial weathering, even in situ, for more than a few thousand years.*[6]

Evidence is against their having been transported as sediments, otherwise one would tend to find them concentrated in stream beds. They are found even on sand dunes, a fact which would rule out stream transport. They could not have been traveling through the universe over a period of 700,000 years and then come to earth 6000 years or so before the present (B.P.), otherwise the entry into the earth's atmosphere at high speed would have erased the fission tracks, which are sensitive to heat, and would have driven off the excess argon, thus re-setting the radiometric clocks. The concluding statement of the Smithsonian report aptly summarizes the dilemma:

> *Having reached an apparently irreconcilable impasse between the physical dating and the geographical dating of the australite fall, one can only turn to the third proposition — something else is wrong. Perhaps this can better be stated as something — some unsuspected factor — has been overlooked.*[6]

To date, a proposed young age for australite infall has not been overthrown.

The last decade and a half have witnessed not only this epoch-making research come to light but also the discovery of tektites in deep-sea cores to the north, west and south of Australia. Because these marine tektites are never as large as their terrestrial counterparts, they are called microtektites, being the size of microfossils, such as foraminifera, which are less than 1 mm in diameter. Interestingly they retain the same general shapes as their larger relatives, ranging from spherical to tear dropped, disk and even dumbbell and spoon shaped.[13] These microtektites spread over a vast area of the ocean bottom are now undoubtedly linked with the influx of australites upon land because of the following salient facts:

1. They have identical refractive indices, which is a measure of the amount that visible light is bent passing from air into the glass, as their Australian counterparts.
2. They have the same range of chemical composition as australites.
3. The shapes of both are much alike.
4. They are dated at identically the same age by the fission-track method — 710,000 years.
5. Occasionally high-magnesium microtektites are found which would correspond with the less common high-magnesium australites.[13,14,15]

The evidence both from petrography and geochemistry strongly indicates that Australasian microtektites belong to the infall responsible for australites.[16,17] That being the case, a careful stratigraphic study of the deep-sea cores in which microtektites have been located should either deny or verify an identically young age for infall. Thus far nineteen Australasian deep-sea cores from widely scattered sites have yielded microtektites.[18,19] For eight of these cores a detailed magnetic stratigraphy has been determined.

Magnetic stratigraphy results from the fact that magnetic particles become oriented in the direction of earth's magnetic field as they fall out of suspension in the quiet water of ocean bottoms. Throughout geohistory the earth's magnetic field has frequently reversed so that the dominant field was not northward but southward. The boundaries between normal and reversed polarity are usually quite distinct in ocean sediments. The most critical boundary in our study is the Matuyama-Brunhes (M-B)

boundary, which was first calculated by the K-Ar method to have been formed 690,000 years B.P.,[20] and more recently has been dated by fission tracks in volcanic ash.[21] Microtektites in large concentrations occur almost without exception in a very narrow stratigraphic range within 10 cm of the M-B boundary.

It appears to be more than a coincidence that microtektites, which have been dated at approximately 700,000 years by the fission-track and K-Ar methods, should be found in a narrow magnetic boundary zone that has been dated both on land and in the oceans at approximately 700,000 years by the same methods. It is for this reason that geologists reject the obvious terrestrial age of 5000-24,000 radiocarbon years as being embarrassingly too young.

The science of stratigraphy, which involves the correlation of cores drilled into the foraminiferal and radiolarian oozes of the ocean bottoms, has now achieved the reconstruction of climatic oscillation patterns on a worldwide basis. Such patterns can be developed irrespective of whether one accepts the validity of any of the dating systems, including C^{14}, applied to the cores. The criteria which are commonly used to match patterns from widely separated regions are described below.

1) *Oxygen isotope ratios*. The ratio of the heavier O^{18} isotope to the lighter O^{16} can be determined very accurately, and it is found that during times of the dominance of polar weather the ratio is higher. The current theory is that when increased amounts of snow accumulated in the far northern and far southern latitudes, the sea levels were lower and hence there would be a relatively higher ratio of O^{18} to O^{16}.[22] Conversely, the melting of the ice caps would release into the ocean the lighter O^{16} that had been incorporated into the snow, thus lowering the O^{18}-O^{16} ratio. The oxygen isotope ratio taken from foraminifera is directly a measurement of sea levels and only indirectly a measurement of paleotemperature. While on land oxygen isotope ratios in some cases seem to be positively correlated with temperature, as, for example, those from a sequence of 87 tree rings in Alberta, Canada, which correlates nicely with weather bureau records.[23] Just this year an 1800-year continuous sequence of Japanese cedar rings has been reported showing oxygen isotope patterns that match with an 800-year sequence from the Greenland ice cap.[24]

2) *Foraminiferal curves*. Foraminifera are one-celled organisms which have a calcium carbonate shell and are a major contributor to the deep-sea sediments. The percentage of polar species to temperate or tropical species can be plotted for the length of the core and a climatic curve developed that correlates nicely with the oxygen isotope curve.

3) *Coccolith curves*. Coccoliths are microfauna that contribute to the oceanic sediments, and, like the foraminifera, the ratios of polar fauna to temperate or tropical fauna can be plotted using the depth of the core as the Y-axis.

4) *Calcium carbonate percentages*. The amount of calcium carbonate ($CaCO_3$) in a given section of the deep-sea core can be accurately determined, and a plot of the percentages shows a good fit with the other factors related to climate. The reasoning is that during times of polar weather dominance the growth of marine organisms which are the major contributors of $CaCO_3$ is inhibited.

5) *Coarse fraction percentages*. This is not the measure of the amount of $CaCO_3$ but a determination of the average size of the calcareous clasts or fragments in the sediment. The theory is that during warm weather dominance the marine organisms grow larger and the percentage of coarse fragments would be higher.

Other methods have been developed and sometimes show a good correlation with oxygen isotope curves, such as the percentages of ice-rafted debris[25] and radiolarians,[26] as well as clay/quartz ratios,[27] quartz/mica ratios,[28] and the coiling ratios of foraminifera.[29,30]

One of the most intensively studied cores of all the thousands of deep-sea cores retrieved to date is the Caribbean V12-122. When the top four meters of the core are evaluated on the basis of the oxygen isotope, $CaCO_3$, coarse fraction and foraminiferal percentages, the resultant curves show fairly good parallelisms (Figure 1). Note that in this diagram as in all diagrams a fluctuation of the curve to the right denotes warm weather (W) dominance and to the left polar dominance (C).

Not only can paleoclimatic curves be developed for oceanic cores but also for terrestrial cores. One of the most problematic of all terrestrial cores has been that of Tenaghi Philippon, Macedonia, which was drilled through 120 m of lake bottom and marsh sediments. Large sections are composed of peat. It would be difficult to compress the amount of time needed for peat formation into a short chronology, unless one were to postulate that this particular peat were the product of diluvial action; in other words, an allochthonous peat. Also, more than a dozen radiocarbon determinations have been made on the top few meters of the core and a reading of 47,670±2700 years has been obtained at a depth of 16.75 m.[31] Assuming a constant sedimentation rate of 25 mm/10^3 years computed from the upper 17 m and extrapolating this rate to the base of the 120 m core, one would conclude that 342,857 years of time are represented. How can this be harmonized with a short chronology of just a few thousand years for post-diluvial time?

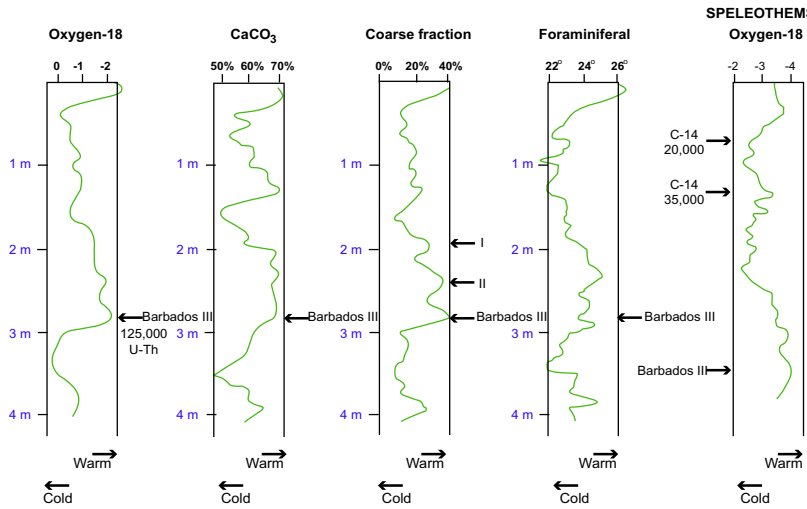


FIGURE 1. Four independent temperature curves for the Caribbean core V12-122 show similar fluctuations (W=Warm, C=Cold). The 3-m level has been dated at 127,000 years by Th^{230} and Pa^{231} (36) and has been correlated with Barbados terrace III which is dated at 125,000 years.[37] The fifth paleoclimatic curve is derived from two stalactites in New Zealand. (Re-drawn from references 45, 46, 33.)

Also of interest is correlating the climatic curve derived from this terrestrial core with various oceanic cores. To develop a climatic curve for land deposits one must use pollen as a temperature indicator. It has been discovered that the percentages of arboreal or tree pollen (AP) and of nonarboreal pollen (NAP), which is composed of grasses, herbs, and shrubs, are excellent climatic indices during historical times. Thus it is suggested that in pre-historic times the higher the ratio of AP to total pollen the warmer the climate would have been, and the higher the ratio of NAP to total pollen the cooler the climate. Thus a plot of AP and NAP percentages as a function of depth builds a climatic curve that can be cross-referenced with the deep-sea curves.

The question is whether it is feasible to match terrestrial curves with the deep-sea. A comparison of the two sets of curves indicates that the resultant curves have a very close fit, considering that they are constructed using different parameters. The Philippon core can be matched with the deep-sea core Al 189, which was retrieved from the central part of the Mediterranean Sea (Figure 2). Another terrestrial core that extends even longer than the Philippon core is the 190 m Sabana de Bogota core from

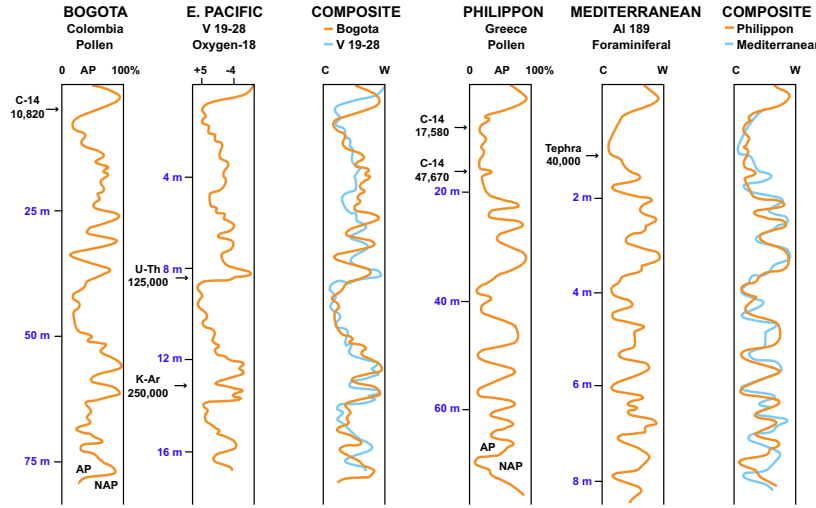


FIGURE 2. Correlation between two terrestrial pollen curves and two marine climatic curves from adjoining ocean basins is demonstrated. The Philippon core is dated with radiocarbon and V19-28 is dated stratigraphically by a distinct ash marker. AP=Arboreal Pollen, NAP=Nonarboreal Pollen. (Drawn from information in references 47, 32, 47, 48 respectively.)

Colombia, South America. Its climatic curve constructed out of AP/NAP ratios has a good fit with the deep-sea curve from core V19-28 which is based on oxygen isotope ratios (Figure 2). Located not far off the coast of Ecuador in the Panama basin, core V19-28 has an ash layer at 13.2 m that has been dated in the range of 225,000 to 250,000 years by four different methods, including K-Ar.[32]

Oxygen isotope curves can not only be derived from marine cores but also from terrestrial speleothems. A curve based on two stalactites from Waitomo, New Zealand, and dated by C^{14} dating is compared with the Caribbean V12-122 curve, indicating that matching can be done on a worldwide basis (Figure 1).[33] Short segments of speleothem oxygen isotope curves from North America that have been dated by Th^{230}/U^{234} match nicely with cores V12-122 and V19-28.[34]

Are such synchronizations of climatic curves mere coincidences? Hardly the case. If these curves were analyzed from the standpoint of probability theory there is only a very slight possibility that even two of the cores could be matched purely on the basis of chance alone. The probability that more than two cores could be coordinated if the curves were not climate dependent would be so small that it can be safely said such curves are indeed controlled by a common variable such as climate rather than by chance processes.

Correlation between widely separated curves can be achieved by noting faunal boundaries, relationships to magnetic reversals, and the presence of volcanic ash layers. Extinctions of certain deep-sea organisms occur at the same interval in matching cores on a worldwide basis. The most convincing example of this is the global extinction of the coccolith *Pseudoemiliania lacunosa* which occurs at the same interval on matching oxygen isotope curves from seven cores, including V28-238 and K708-7 (see Figure 3).[44] One would not expect such precision if the deposition patterns were catastrophic and non-uniform.

The best way for such cores to be matched is by postulating a fairly uniform rate of deposition. If the rate is apt to vary at certain segments of the core by a factor of more than 2 or 3 either below or above the average rate for the whole core, then the curves would not show a close fit. Thus it can be concluded that the sedimentation rates have varied from each other on an average less than a factor of 2 for any significant portion of the cores in Figure 2.

If the rates have been fairly uniform in order to produce a good fit for all these curves, then based upon the present rates of sedimentation the cores would depict a chronology many times longer than the traditional Biblically oriented chronology of 4300 to 5000 years for post-diluvial time. How does one solve this time problem if he wishes to maintain a conservative creationist approach to the subject? In probing for a solution, it is imperative that we first match these shorter core lengths with much longer sequences that extend to the M-B boundary. If that can be accomplished, we can take the tektite-determined age for the M-B boundary as a reference point for dating all deep-sea deposits that are above it.

What we have done is to select cores from widely scattered geographical areas to determine indeed if climates have fluctuated on a worldwide basis during the period of time which geologists have assigned to the Pleistocene. Of the eight cores represented in Figure 3 three extend to the M-B boundary. Of the other five, two are the longest terrestrial cores with a continuous pollen record — Sabana de Bogota of northern Colombia and Tenaghi Philippon of northern Greece. There is a very good match between the Bogota core and the North Atlantic K708-7, and another fine match between the Philippon core and the West Pacific V28-238, showing that terrestrial and deep-sea cores indeed can be correlated. Again it would be most difficult to argue that such matching is purely the product of chance. The sediments of these cores most likely accumulated *in situ* and provide a fairly reliable picture of temperature at the moment of their deposition. Otherwise, if they were not *in situ*, or autochthonous, then the temperature curves would show a scrambled picture due to catastrophic activities.

The most intriguing aspect of the cores is the variety of dating methods that have been applied to them. The most commonly used method, the C^{14}, exceeds its usual limit of 50,000 years at a depth of less than one-tenth of the way down to the M-B boundary. Core RC11-209 yields a radiocarbon date of 11,600±600 years at a depth of only 11 cm, which would give a sedimentation rate of 1 cm/10^3 years.[35] Extrapolating this average rate to the M-B paleomagnetic boundary which occurs at 6.9 m in this particular core, the result is a figure of 690,000 years. It should be noted, however, that generally C^{14} extrapolated rates do not harmonize so precisely with paleomagnetic data, which are based largely on K-Ar and fission-track dating of terrestrial lavas.

Other dating methods that have been used to determine the placement of the M-B boundary either through extrapolation or interpolation are uranium disequilibrium methods, fission tracks, K-Ar, obsidian hydration, and amino acid epimerization. The first three are radiometric, and the last two involve geochemical reactions with many variables. Two of the uranium disequilibrium methods involving Th^{230} and Pa^{231} have been applied to the Caribbean core V12-122 and yield concordant sedimentation rates of 2.35 cm/10^3 years.[36] It should be noted that uranium disequilibrium methods have not always yielded consistent results. This would date the end of the next-to-the-last polar dominance, known as Termination II, at 127,000 years (Figure 1). A recent report has correlated the high warm climatic peak that occurs immediately after Term II with a raised coral reef, which is called Barbados III and is dated at 125,000 years by Th^{230}/U^{234}.[37] The correlation is accomplished by an oxygen isotope analysis of mollusks from the raised coral reef and by a comparison with oxygen values from deep-sea cores, such as V28-238, which suggest a warmer climate than present and thus higher sea levels for that episode of reef growth. Actually there are three Barbados terraces, the other two being dated at 82,000 and 105,000 B.P. by the same method. These three terraces can be easily correlated with the three successive warm fluctuations just above Term II seen especially well in the Philippon and Bogota curves (Figures 2, 3).

Volcanic fragments in deep-sea cores have been dated by two methods; the fission-track method generally yields concordant results with the paleomagnetic age,[38,39] while the K-Ar results from a core that has microtektites are discordant with the paleomagnetic age.[40] Two other dating methods that as yet have not achieved the stature of the radiometric methods because of non-constant rates of chemical change are obsidian hydration and amino acid epimerization (racemization), the former having been applied to several Pacific cores,[41] and the latter to cores V12-122 and V28-238 which are dealt with in our study.[42,43]

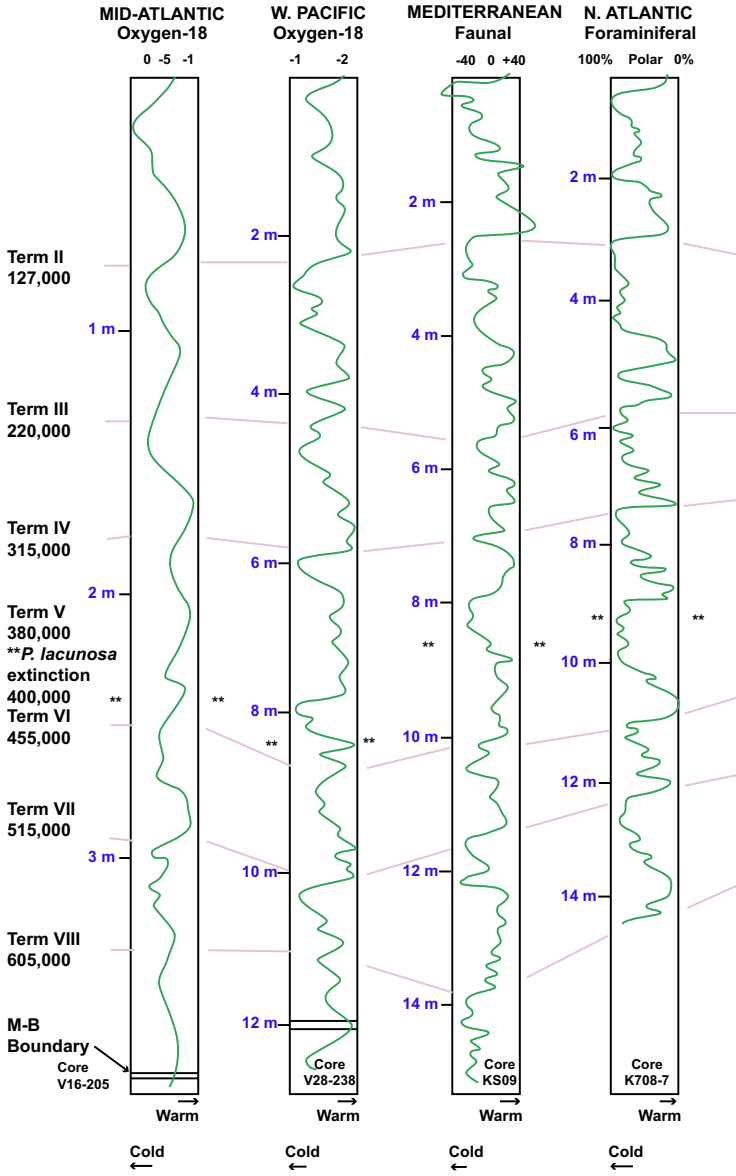
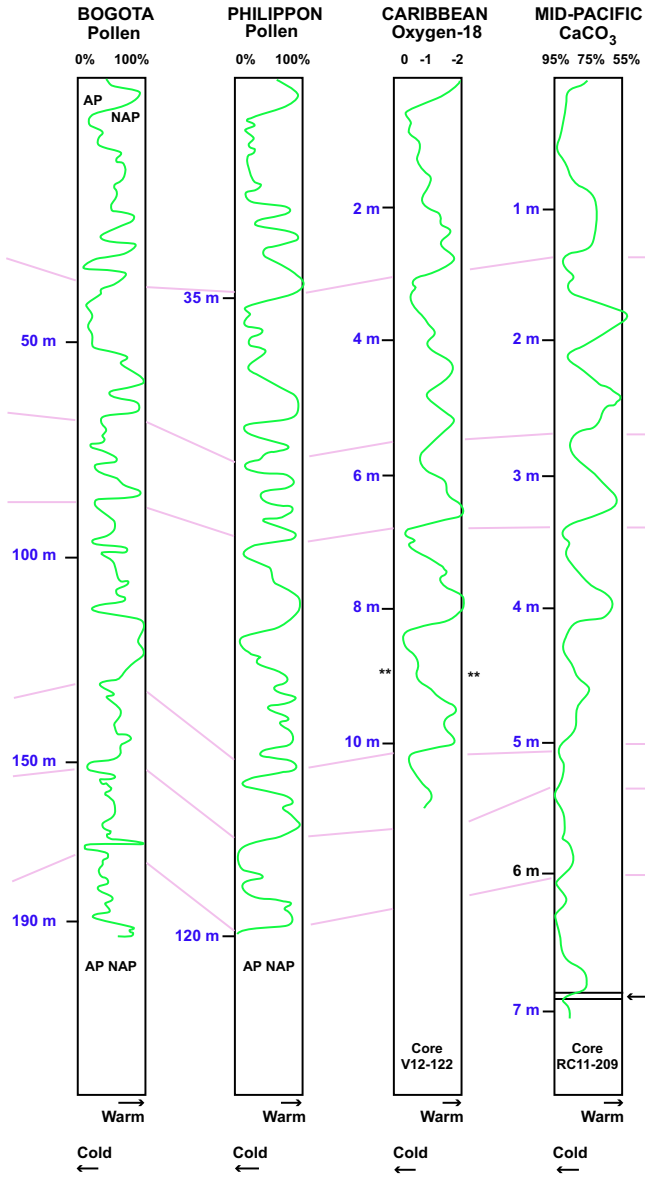


FIGURE 3. The possibility of worldwide correlation is shown by comparing paleoclimatic curves from six marine and two terrestrial cores which span most of the Brunhes magnetic era during which the earth's magnetic field showed normal polarity. The M-B, or Matuyama-Brunhes boundary, marks the transition from reversed to normal polarity. The transition form glacial-type conditions to



warm weather is denoted by "Terminations." The *Pseudoemiliania lacunosa* extinction occurs about midway in the Brunhes and serves as a worldwide stratigraphic marker. (Re-drawn from information in references 48, 50, 41, 52, 47, 47, 45, 35 respectively, left to right.)

If we simply take at face value the above-mentioned dating methods that have been applied to deep-sea cores, it confronts us with a strong case for the reliability of their conventional age interpretation. Thus it is important that some concrete, verifiable explanation be advanced in order to maintain a short chronology based upon Biblical data.

Since the first paleomagnetic boundary is worldwide and occurs at consistently the same location on the paleoclimatic curves, this can be utilized as a useful time marker. If the microtektites can be positively linked with the same event as australite infall and if radiocarbon dating serves to limit the age of infall to about 5000 or 6000 radiocarbon years ago, then we are forced into dating the M-B boundary at 5000 or 6000 radiocarbon years ago.

This tentative conclusion is valid only to the degree that our techniques of correlation are scientifically sound. Like a steel chain, correlation is no stronger than its weakest link. What we have done is to encircle the earth with our stratigraphic "chain" in the following way: first, link the australites on land with the deep-sea microtektites as part of the same infall of tektites; then the microtektites with the M-B boundary, which is usually placed at 690,000 years; the M-B boundary from cores in the Australasian area with the M-B boundary in cores around the world; and finally connect the deep-sea cores with the terrestrial.

If we assign an age of approximately 5000 B.P. for the M-B boundary, then the chronology for all Pleistocene paleoclimatic curves above that boundary would have to be compressed 140-fold from the conventional age of about 700,000 years. The most problematic Pleistocene core, that of Tenaghi Philippon, would likewise have to be reduced 140-fold. The C^{14} age of 47,670 at 16.75 m must be reduced accordingly to 340 years. Such a drastic reduction is not possible in light of the fact that C^{14} ages can be correlated with Egyptian chronology at least 3800 years into the past; thus at most there can be a 12-fold reduction if the figure of 3800 years is taken as the minimum time for major disagreement between C^{14} age and real time, as the evidence seems to indicate. This takes care of only the upper one-seventh or 17 m of the core, leaving more than 100 meters below. If we compress the C^{14} age at the 17 m level to the minimum allowable (3800 B.P.), then the age for the bottom of the core would be placed at approximately 26,600 B.P. (7×3800), which far exceeds the maximum age of 5000-6000 allowed by microtektite evidence. Therefore, the C^{14} stratigraphy at Philippon does not allow the compression of the Pleistocene time-scale to the degree demanded by C^{14} stratigraphy of australites found *in situ* in southeast Australia. It seems that we are confronted with two incontrovertible, yet incompatible, pieces of evidence.

Dilemmas such as this serve a much-needed purpose in forcing us to grapple with the problem and to begin earnest painstaking effort at working toward a solution. Further research is urgently needed to either eliminate or confirm any of the above. Let this study be a challenge to creationists to probe into the "uttermost parts of the sea" and the "recesses of the deep" (Psa 139:9; Job 38:16) to find adequate answers. In pursuing the footsteps of the Creator even into ocean depths, who knows whether a totally new solution may be uncovered that at present is overlooked! Only time will tell.

SUMMARY

If further research continues to validate the youthful age of australite infall, then six apparently interlocking dating methods applied to deep-sea cores must undergo complete revision, resulting in a drastic reduction of Pleistocene chronology and a greatly increased sedimentation rate for all but the uppermost deposits — at least 140 times above present rates. An acceptance of the australite infall age of 5000-6000 years B.P. determined by C^{14} and its worldwide application through paleomagnetic and paleoclimatic correlation has implications that would challenge virtually every radiometric and non-radiometric dating method applied to cave and sedimentary deposits. Thus the present dating methods based upon fission tracks, K-Ar decay, uranium-series disequilibrium (protactinium and thorium), amino acid epimerization, obsidian hydration, and paleomagnetism may stand or fall depending upon future studies into the vast shower of tektites and microtektites in the Australasian region.

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NEWS AND COMMENTS

APPEAL FOR EQUALITY

Although legal decisions in some parts of the U.S. have hampered efforts to have creation presented in the public schools as an alternative theory to evolution, the struggle continues. Creationists are seeking ways in which to use the negative court rulings to their advantage. An Indiana court has ruled that the teaching of creation theory in the public school classrooms violates the U.S. constitutional provisions for separation of church and state and, further, that the use of the Creation Research Society text *Biology: A Search for Order in Complexity* gives a biased treatment of origins by promoting creation theory over evolution (see *Origins* 4:46-49).

Because an appeal of the Indiana decision would probably be futile, and following the example of creationists in California, members of the Indiana Farm Bureau plan to petition for an evaluation of all science textbooks for bias in promoting evolution as the answer to the question of origins. It is hoped that all dogmatic statements about evolution will eventually be removed from the textbooks.

Even if the courts were to rule in favor of teaching creation, additional problems would have to be solved. One drawback has been that teachers lack both training and textbooks to use a two-model approach to the subject of origins. A possible remedy is currently being developed. In Kanawha County, the largest school district in West Virginia, the Board of Education has voted to adopt a creation-science model from grades K-12 in presenting origins. To implement this model, the Board has commissioned Robert E. Kofahl of the Creation-Science Research Center in San Diego, California, to prepare at three-unit, graduate-level course to train the teachers in the methodology of presenting a neutral two-model approach in the public school classrooms. Dr. Kofahl is currently preparing a detailed syllabus for the course. Topics covered in this syllabus will include the philosophical and logical problems in the creation-evolution controversy, legal issues of teaching creation theory in the science classes, examination of the scientific evidence for both creation and evolution models, and pedagogy involved in the two-model presentation.

If this course meets favorably with the Board of Education and is included in the university system of West Virginia, it could set an example for other states to follow in the continuing battle to see that theories of origins are presented fairly and equally.

Katherine Ching

NEWS AND COMMENTS

A NEW JOURNAL ON CATASTROPHISM

In 1785 James Hutton of Edinburgh published the epoch-making book *Theory of the Earth* in which he proposed that present geologic processes were responsible for past changes in the surface of the earth. This concept is in contrast to the then-prevailing idea of one to several major catastrophes as the most important past geologic agents. In 1830 the English geologist Charles Lyell originated the term "uniformitarianism" to describe Hutton's views. The concept is succinctly stated as: the present is the key to the past. This uniformitarian principle has dominated geological thought in a fairly strict way for nearly two centuries while the opposite view, called "catastrophism," has been considered unacceptable.

Recently, however, there has been a serious trend towards catastrophism in geological thinking. Though not a return to the classical catastrophism consisting of a few major worldwide events, catastrophes are now commonly being accepted as geologic agents, while strict uniformitarianism is being downgraded largely by redefining the term so that it applies to the principles of science rather than to geologic processes. It is no longer considered that the present geologic processes represent the only way geologic features were formed in the past.

Evidence of this trend appears in a new journal entitled *Catastrophist Geology*. Published in Brazil by Johan B. Kloosterman, the journal has an impressive list of editors and assistants mainly from Europe and the U.S.A. It is "dedicated to the study of discontinuities in earth history." This journal does not intend to be conventional. It also aims at publishing on subjects neglected or tabooed in the mainstream geological literature; its tone sometimes indicates that its editors would not mind causing a catastrophe themselves. Only two issues have appeared thus far. The first one deals more with basic issues of conventional science, while the second one has more information dealing with catastrophes.

Included in the contents of the first issue are articles entitled: "Scientific Censorship and Thought Control" and "Whimsical Aspects of Scientific Theory." This issue also contains a long section of interesting, though somewhat redundant, responses to the announcement of the publication of the journal. The second issue starts with a significant section in readership response to the first issue. Articles include: "Catastrophism and Uniformitarianism," "Mass Movements in Level Areas," "Overnight Valley Formation in São Nicolau," and "The Martian Deluge."

The journal is to be commended for breaking away from traditional constraints. It is of great interest to anyone concerned with catastrophism

or seeking for new geological ideas and explanations. It is hoped that its editorial policies will not take it too far from the control of empirical data.

Catastrophist Geology can be obtained by writing to the publisher, Johan B. Kloosterman, Caixa Postal 41.003, Rio de Janeiro, Brazil. Cost for "four biannual issues" is U.S. $10 (NOTE: Thus far *Origins* costs less!).

Ariel A. Roth

LITERATURE REVIEWS

Readers are invited to submit reviews of current literature relating to origins. Mailing address: ORIGINS, Geoscience Research Institute, 11060 Campus St., Loma Linda, California 92350 USA. The Institute does not distribute the publications reviewed; please contact the publisher directly.

TRACING THE TALES

THE TWO-TALED DINOSAUR. Gerald Wheeler. 1975. Nashville, TN: Southern Publishing Assn. 224 p.

Reviewed by Ian M. Fraser, Chairman
Department of Physiology and Pharmacology,
Loma Linda University

As the title cleverly suggests, this book attempts to show that the remains of dinosaurs in the rocks (along with all of the other fossils) can be interpreted in at least two ways. The primary thrust of the author is to trace the historical development of ideas relating to the interpretation of the fossil record. In a limited sense, he has written a Christian version of *The Death of Adam* (Greene JC. 1961. NY: The New American Library). However, after exploring this theme from ancient times through the nineteenth century in the first five chapters, the author jumps to current controversies about the teaching of creation and textbooks in public schools in the United States. Then he shifts to an exposition of the limitations of the scientific method, particularly the limitations of scientists themselves. Finally, we are offered two appendices in which the author expounds on his own views concerning the inspiration of the Genesis account of creation and a scientific approach to the fossil record as the product of a worldwide flood.

Although there is a certain flow of thought and relationship throughout the book, one is left with the feeling that the author has made a book out of a collection of somewhat unrelated essays written relatively independently. There is a certain disjointedness and discontinuity that leaves one slightly bothered for not very good reasons! This is not to say that the author does not make a useful, even significant contribution in all the areas he touches; one is just left wishing that he had developed his theme more completely.

Personally, I found the first five chapters the most interesting, even though the author's style is a little boring at times (as is the reviewer's). Being in no sense an authority in this field, some of the information was new to me and some of the interpretations and insights were distinctly original and innovative. Starting with the Egyptians and the Greeks,

Wheeler presents the history of the development of ideas about origins and the fossil record through the medieval period to Reformation times. The conceptual framework in which Darwin and Wallace worked is well presented and contrasted with the views of Paley and others of those times who developed the so-called natural theology. The decline of diluvialism and the rise of uniformitarianism which followed is clearly portrayed. This historical section of the book concludes with a chapter devoted to the view that a theory is a personal thing, with Darwin and Huxley as star examples.

Wheeler shifts gears in the next two chapters. Instead of continuing his historical approach into the events of the twentieth century in the evolution-creation controversy, he jumps into the current textbook controversy in California and elsewhere. I suppose this is intended as a sample of recent history, but I would have preferred a more comprehensive analysis of the last seventy years. Although the uniformitarian hypothesis has dominated the field in these recent years, it would be useful to bring together the work of isolated scientists around the world who have supported the creation viewpoint in their publications. This would probably require a good deal more research in the original literature than was necessary to write the first five chapters. Most of the information in these chapters is available in the secondary sources cited by Wheeler.

The last chapter entitled "Science Is No Greater Than the Scientist" makes many good points, but I must take issue with the implications of the title. Science *is* greater than the scientist. As a practicing scientist in at least a modest way, I am probably more intimately aware than is Wheeler of the fact that science is a very human enterprise. Individual scientists are often ambitious and devoted to proving their pet theories. But to imply that science as a collective enterprise is no better than the individual scientist in this respect is a fundamental error. In nearly every area of research we find several scientists or groups of scientists attacking the same problem. They rarely agree on all the details and often not on major findings in the field. Their associates in the discipline who hear their reports or read their papers are thus provided with a spectrum of data and theory. Ultimately, a viewpoint in the field is synthesized which is greater by far in intrinsic scientific merit and even truth than that of any one scientist. This situation is not unique to science; in any field of scholarly endeavor the broad concepts and information are significantly greater than those of any one scholar with his human failings.

Wheeler is not the first apologist for the creationist position to adopt this viewpoint of science as proof that we must turn to inspiration as our only source of definitive knowledge of origins. But Wheeler and his associates tend to ignore the fact that a scholarly approach to inspired documents might have the same problem. To paraphrase Wheeler, "Theology is no

greater than the theologian." But the collective conservative scholarship which has been applied to Genesis surely exceeds the biased scholarship of a single investigator. It has been remarked that creationism has been impeded by the messianic complexes of its proponents. But creationism, too, can be greater than the creationist. All the foregoing should not be construed to mean that I do not consider science to be limited in its ability to arrive at truth as Wheeler, in fact, points out quite well in this chapter.

The two appendices to the book could have been regular chapters, since they are as relevant to the theme of the book as some of the other chapters. Appendix A presents a well-reasoned defense of the inspiration of the Genesis creation account as compared to other early documents with their many absurdities and inconsistencies. The author is to be commended for attempting an exposition of the basic philosophical position of creationists on the value and nature of inspired sources. Some other recent authors have failed to treat this area and left the reader to assume their rationale.

Appendix B presents Wheeler's view of the flood theory paradigm. He makes many good points but does not follow the scholarly approach of earlier chapters. It is unfortunate that he passed up an excellent opportunity to write a current historical analysis of this area which would have complemented the earlier sections of the book. The previous contributions of creationist scholars to this flood paradigm are not mentioned or referenced. This oversight poses him as the only source of a flood paradigm with the implication that no one else has ever thought about this or written anything on it.

The most glaring omission in the book, however, is the absence of even the slightest reference to the time frame for earth history and the scientific dating of the fossil record. One infers Wheeler's acceptance of a short chronology for earth history but wonders how he managed to exclude so thoroughly all reference to the opposing viewpoint. From the standpoint of the evolutionist, there is another tale that the dinosaur tells which Wheeler chooses to ignore. Considering the complexity and the sophistication of the field of radiometric dating, one can understand that he might be reluctant to undertake a historical analysis of this area. But to not even acknowledge the problem seems unwise.

I undoubtedly owe an apology to Wheeler and those who have been helped by the book for writing the preceding several paragraphs. Wheeler has made a significant contribution to scholarship in the field of creationism, particularly in terms of the history and development of the evolution-creation controversy. As further study of some of the other areas is undertaken by the growing body of well-trained creationist scientists, it should become possible to present a more definitive tale of the dinosaur in which inspiration and science find deep agreement.

LITERATURE REVIEWS

Readers are invited to submit reviews of current literature relating to origins. Mailing address: ORIGINS, Geoscience Research Institute, 11060 Campus St., Loma Linda, California 92350 USA. The Institute does not distribute the publications reviewed; please contact the publisher directly.

IS A YAK A BUFFALO?

VARIATION AND FIXITY IN NATURE. Frank L. Marsh. 1976. Mountain View, CA: Pacific Press Publishing Assn. 150 p.

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Tigers and lions, zebras and horses, foxes and jackals, rats and mice; are they related? Did each pair diverge from a single created prototype or did they begin existence as independent creations? There is now little doubt that divergence (microevolution) has occurred, but how far can it go and what is the origin of the variant genes?

The conservative creationist is under some obligation to account for the variety of characteristics in groups of related organisms found in the world today. The constraints within which he must work are quite demanding. First, all the forms of life he observes must have descended from those that came into existence at the word of God. Second, he accepts the judgment of the Creator that all He made was "very good." (He usually assumes, for instance, that life was under a more benign control than we find today. Population densities were probably controlled by internal regulation of individual growth and reproduction rather than by starvation, predation and disease.) Thirdly, respect for the inspired accounts leads him to believe that the history of life on this planet is measured in a few thousand rather than billions of years.

If he tries to reconstruct the descent of modern organisms from their created prototypes (hereafter called *baramins* at Marsh's suggestion) the creationist is faced with some intriguing questions. Are there limits to the amount of change that has occurred in each line? How far have subgroups derived from one *baramin* diverged from each other? Can they still be recognized as having the same created ancestor? What criteria might be used to assign living organisms to one line or another? These are some of the topics Dr. Marsh addresses in his book.

At its core the book presents a proposal: the suggestion that modern organisms can interbreed only if they are members of the same *baramin*. This opinion is based upon a particular interpretation of the word "kind"

in the King James Version of the Old Testament. If two individuals from different *baramins* were to interbreed and produce an offspring, in Marsh's opinion the new individual would not be of the same "kind" as either of its parents, and such an occurrence would violate the divine command that individuals were to "bring forth after their kind." To accomplish His design, Marsh concludes, the *baramins* were biologically incapable of cross-infertilization and remain so today. Representatives of a single *baramin*, no matter how far they have diverged since creation can, at best, cross-fertilize only with individuals from the same created ancestor. By testing reproductive compatibility at the level of gametic fusion we should be able to sort out modern groups which have descended from a single prototype.

Of course, minor alterations in reproductive chemistry might abolish compatibility between some members of a *baramin*. Consequently, Marsh proposes that negative results cannot be reliably interpreted. The tack is to determine the extent of variation by looking for positive results between organisms. The data so far indicate that some *baramins* include organisms currently placed in different genera and even different families.

If Marsh is correct and gametic fusion can be used to detect the members of a *baramin*, what mechanisms could account for the differences between members? It is easy to imagine how wolves and dogs came from the same ancestor (along with coyotes, jackals, dingos and foxes), but what about less similar types such as turkeys and domestic hens, wheat and rye, pheasants and ducks?

One of Marsh's basic principles is that the degree of divergence of modern organisms from their prototypes is limited. Although nearly all the characteristics of a *baramin* vary in different individuals, the effect of sorting the alternatives in various ways always results in individuals that bear a strong resemblance to one another. Though Marsh is unable to provide us with a creation-centered explanation for variation or to define its limits in molecular terms (he has difficulty distinguishing somatic cell hybridization from DNA hybridization) there is no lack of possibilities. One possible explanation is that most of the viable variants of each gene were created and were present in various individuals of the created population or in some other biological reservoir (viruses, perhaps). Random assortment of the created alleles would result in novel combinations which could account for the appearance of such diverse modern forms as radishes, cabbage, cauliflower and brussel sprouts from a single *baramin*. To this may be added the effects of completely new gene forms generated by mutation, though mutation may actually be a relatively minor source of viable alleles. (Mutation, in its current manifestation, may not have been an intended part of creation since it generates deleterious alleles as

indiscriminately as "neutral" or "good" ones. Available evidence would suggest that mutation is a singularly uncreative process.) The limits of a *baramin*, then, would be largely determined by the number of different alleles for each gene designed at Creation.

The book does have its problems. One of the most persistent is the confusing use of the word "species." The author points out that species designations are largely arbitrary taxonomic groupings. From the creationist point of view the group of organisms descended from the created prototype or population should have the name "species." (That was the intent of the early taxonomists who were, incidentally, creationists.) Since the word has been corrupted by long misuse Marsh proposed the word "*baramin*" thirty-five years ago. Unfortunately the author has not taken himself seriously and throughout the book uses the word "species" when he means "*baramin*," to the reader's confusion. At one point (p 20) he criticizes Darwin for having written, "'I look at the term species as one arbitrarily given,'" because he read "*baramin*" where Darwin wrote "species." The same confusion results when he mentally redefines the phrase "polytypic species" to mean "*baramin*" and applies it retroactively without warning the rest of the taxonomic world (p 31).

The author occasionally trivializes or misstates the evolutionary position. Of course, we would be "flabbergasted" (p 42) if a milk cow should deliver a colt, or if a chicken egg hatched a duck. So would evolutionists! They never postulate such occurrences. We would be equally startled to find a cabbage growing from radish seeds or to deliver a buffalo from a milk cow, yet these are changes which Marsh believes to have occurred. Clearly he does not envision them as happening in a single step. Why does he require such single-step changes of evolutionists?

The book profitably focuses our attention on the important topic of biological variation, its origins and limits. Marsh's proposal, if supported by careful Biblical and laboratory investigation, may answer some of the questions which have perplexed creationists for years.

GENERAL SCIENCE NOTES

DO RABBITS CHEW THE CUD?

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WHAT THIS ARTICLE IS ABOUT

This is an example of a purported error in the Bible. Leviticus 11:6 states that the hare chews the cud, while scientific information is generally believed to dispute the statement. However, there are more recent findings regarding the digestive patterns of the hare. Like the cow, it has a fermentation chamber with microorganisms to digest plant material. The hare and others of its type produce two kinds of fecal pellets; one kind is reingested and temporarily stored in the stomach until redigestion takes place, thus increasing the efficiency of food intake. This is quite similar to what goes on in the cud-chewing animals, like the cow, except that travel of the partially digested food is outside the body instead of a reverse internal pattern as found in the cow.

Leviticus 11:6 is sometimes used as an example of an error in the Bible; it states that hares chew the cud. Hares are not usually known as cud-chewing, or ruminating, animals. Is this really an error in the Bible, or did Moses know what he was talking about?

When a cow swallows a mouthful of grass, it goes first of all to one compartment of the stomach referred to as the rumen. The culture of microorganisms that exists in the rumen digests the grass and converts much of it into nutrients which the cow can utilize. Then the cow brings the microorganisms and leftover grass back to her mouth, one mouthful at a time. She chews it and sends it on through the rest of her digestive tract. Thus the cow really doesn't subsist directly on grass alone, but also on the protozoa and bacteria that she breeds in her rumen (Carles 1977).

The process of digestion of grass by microorganisms is referred to as fermentation, and it occurs in many other animals besides the cloven-hoofed ruminating animals. Special forestomachs for fermentation are also found in kangaroos, whales, dugongs, hippopotamus, sloths, and colobid monkeys (McBee 1971). Other modifications of the stomach or some part of the intestines to provide a fermentation chamber are found in rodents, rabbits and hares, gallinaceous birds, horses, hyrax (McBee 1971), and in mallards (Miller 1976).

Some herbivorous animals consume part of their own feces, thus recovering fermentation products that have passed through the digestive tract. This process of reingestion of feces occurs in many rodents (Thacker & Brandt 1955) and in all genera of hares and rabbits (Carles 1977, Hamilton 1955, Kirkpatrick 1956, Lechleitner 1957, McBee 1971, Myers 1955, Southern 1940, Watson 1954, Watson & Taylor 1955). Reingestion of

feces is an especially well-developed practice in Lagomorphs (rabbits and hares) and is important for their adequate nutrition.

Lagomorphs produce two kinds of fecal pellets which are produced at different times during the day. When the animals are active and feeding they produce the familiar hard pellets. When they cease their activity and retire to their burrows or resting areas, they begin producing soft pellets which they eat as soon as they are passed (Myers 1955). Rabbits reingest 54-82% of their feces (Eden 1940), which they apparently swallow whole, without chewing (Watson 1954). The soft pellets are composed of material from the fermentation chamber, which in the Lagomorphs is located in the cecum, a blind pouch at the beginning of the large intestine (McBee 1971). The soft pellets are composed mainly of bacteria, mixed with some plant material, and each pellet is enclosed in a proteinaceous membrane secreted posterior to the colon. These tough membranes remain intact for at least six hours after reingestion. When swallowed they pass to the fundus portion of the stomach, where they remain for several hours (Griffiths & Davies 1963). Other food that is swallowed moves past the accumulation of soft pellets and goes on through the digestive tract. The membranes around the pellets and a buffering solution in the pellets control the pH, so that fermentation continues in the pellets even though the rest of the stomach is acid (Griffiths & Davies 1963).

The process of cecal fermentation and reingestion helps the rabbit in several ways. Amino acids and proteins are synthesized by the bacteria in the cecum, using nonprotein nitrogen (perhaps urea). Amino acids are absorbed directly through the walls of the cecum and provide 4.4-21.8% of the animal's daily energy requirement (McBee 1971). Proteins synthesized in the cecum are carried to the stomach in the soft pellets. This protein is important to the nutrition of the rabbit. Experiments have shown that "nitrogen balance in the rabbit was reduced 50% if soft feces were not eaten" (McBee 1971). Fermentation and reingestion also improve utilization of sodium and potassium and provide 83% more niacin, 100% more riboflavin, 165% more pantothenic acid, and 42% more vitamin B_{12} than would be available if soft feces were not consumed (McBee 1971, Myers 1955).

Is this special digestive process analogous to the rumination, or cud-chewing, in cows? There are both similarities and differences between the two processes. The rabbits are different in that they do not have a four-part stomach with a rumen, and the material that reaches their fermentation chamber has already been chewed and partially digested. Cows and rabbits are similar in that they both have a fermentation chamber with microorganisms that digest otherwise indigestible plant material and convert it to nutrients. Some of the rabbit microorganisms are different from those in cows, but many of them are the same or similar (McBee 1971). Both cows and rabbits also have a mechanism to pass the contents of

their fermentation chamber back to the mouth and then on through the digestive tract.

Madsen (1939) wrote an article entitled "Does the Rabbit Chew the Cud?" Southern (1940) concluded that reingestion has an advantage to the rabbit "equivalent to 'chewing the cud'." Griffiths & Davies (1963) concluded that "we consider that the fundus of the rabbit stomach, loaded with soft pellets, is analogous to the rumens of sheep and cattle."

Carles (1977) compared cows and rabbits and reached the conclusion that rumination should not be defined from an anatomical point of view (the presence of a four-part stomach), but rather on presence of an adaptation for breeding bacteria to improve food. On this basis he stated that "it is difficult to deny that rabbits are ruminants."

What is the correct explanation for Leviticus 11:6 — is it an error in the Bible, or is it evidence that Moses had a source of information far ahead of his time? Since rabbits and hares have a process that is so similar to cow rumination that it becomes a question of the technicalities of one's definition of rumination, it would be difficult to justify interpreting Leviticus 11:6 as an error in the Bible.

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