# EDITORIAL

## THE POTENCY OF PREVAILING CONCEPTS

In a recent public discussion on a state university campus in the eastern United States, a genetics professor who teaches the basic course in evolution at that institution stated that the developments in molecular biology have established that Charles Darwin was wrong in the mechanism he proposed for an evolutionary development of life. This professor went on to say that although there is at present no evidence that clearly supports an origin and development of life by naturalistic processes, there is no justification for saying that an evolutionary or non-theistic explanation for life is incorrect; the task facing the scientific community is to find new explanations concerning how evolution did occur, not to abandon the concept.

Three aspects of these comments deserve consideration. First is the recognition that despite what are often strong claims to the contrary, the accumulation of scientific evidence has been increasingly unfavorable to mechanistic evolutionary concepts of origin. Professor D. E. Green of the Institute for Enzyme Research at the University of Wisconsin and Dr. R. F. Goldberger, chief of the Biosynthesis and Control Section, Laboratory of Chemical Biology, U.S. National Institutes of Health, in their book *Molecular Insights Into the Living Process* say that "...the macromolecule-to-cell transition is a jump of fantastic dimensions which lies beyond the range of testable hypotheses. In this area all is conjecture. The available facts do not provide a basis for postulating that cells arose on this planet."[1] Dr. John Keosian of the Marine Biological Laboratory at Woods Hole, Massachusetts, at an international conference on the origin of life held in Barcelona, Spain, in June 1973, said "...the simplest heterotrophic [obtains food from outside sources] cell is an intricate structural and metabolic unit of harmoniously coordinated parts and chemical pathways. Its spontaneous assembly out of the environment, granting the unlikely simultaneous presence together of all the parts, is not a believable possibility."[2]

Professor Marcel P. Schützenberger of the University of Paris has stated "that there is a considerable gap in the neo-Darwinian theory of evolution, and we believe this gap to be of such a nature that it cannot be bridged within the current conception of biology."[3] In a presidential address to the Linnaean Society of London, Errol White, Fellow of the Royal Society, stated: "We still do not know the mechanics of evolution in spite of the over-confident claims in some quarters, nor are we likely to make much further progress in this by the classical methods of paleontology or biology....”[4]

Thus, as stated by L. Harrison Matthews, F.R.S., in his introduction to the 1972 edition of *The Origin of Species* by Charles Darwin, “Belief in the theory of evolution is thus exactly parallel to belief in special creation — both are concepts which believers know to be true, but neither, up to the present, has been capable of proof.”[5]

The second aspect of these comments that deserves consideration has to do with the nature of scientific evidence. The inability to obtain incontrovertible support for a proposition does not eliminate that proposition as a possibility. As an example it may be noted that failure to establish guilt does not guarantee the innocence of an individual charged with crime. Overwhelming evidence for the *possibility* of an evolutionary development of the living forms known today would not guarantee that these organisms are the consequence of such a process. Nor would lack of such evidence prove the contrary.

Science is more effective in showing an idea to be incorrect than in establishing its correctness. Consequently a theory is considered to be more suitable for scientific purposes if it is vulnerable to experimental disproof. In this respect the popular theory of progressive evolutionary development of organisms is being increasingly recognized as a defective scientific concept, since much of it has become irrefutable, regardless of the nature of the data input.[6] Creation theory, it must be noted, from a scientific viewpoint suffers the same defect.

At the level of molecular biology, evolutionary theory is subject to experimental refutation. A naturalistic theory of origins must reasonably account for a transition from relatively simple inorganic compounds to complex biologically active molecules, and for the assembly of a vast array of such components into a functioning cell structure. The understanding of chemical reaction dynamics, allowable primitive earth characteristics, and molecular biology has reached a level that precludes these basic steps in a naturalistic process of evolutionary development. While it is correct to say that the lack of supporting evidence does not *disprove* an evolutionary process as the correct explanation for the origin of the organisms now found on planet Earth, it does indicate a need for an alternate explanation. The above quotations from Schützenberger and White show it to be now well established that a purely evolutionary explanation of origins that does not go beyond the properties presently exhibited by matter is virtually impossible. The evidence favors intelligence, rather than inanimate matter, as the first cause.

Finally, the professor’s remarks which stimulated this editorial illustrate the elements of faith and personal preference that enter into views regarding origins. For many the evolutionary explanation is held regardless of the evidence for or against — it is accepted with faith that rivals the faith associated with the most devoted adherents to abstract religious concepts.

R. H. Brown

## ENDNOTES


1. Green DE, Goldberger RF. 1967. Molecular insights into the living process. NY: Academic Press, p 407.
2. Keosian J. 1974. In: Oro J, et al., editors. Cosmochemical Evolution and the Origin of Life. Dordrecht, Holland: R. Reidel, Dordrecht, Holland. Vol. I, p 291.
3. Schützenberger MP. 1967. Algorithms and the neo-Darwinian theory of evolution. In: Moorhead PS, Kaplan MM, editors. Mathematical challenges to the neo-Darwinian interpretation of evolution, p 75. The Wistar Institute Symposium Monograph Number 5.
4. White E. 1966. A little on lung-fishes. Proceedings of the Linnaean Society of London 177:1-10.
5. Matthews LH. 1972. Introduction to The origin of species by Charles Darwin. London: J. M. Dent & Sons, p x.
6. Bethell T. 1976. Darwin's mistake. Harper's Magazine 252(1509):70-75.

# 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: Wheeler: The Cruelty of Nature (*Origins* 2:32-41)

To be sure, as Wheeler brought out, the cruelty and savagery of not only the plant and animal world, but more especially of the human world, is often used as a reason to dismiss a creator. However, questions about cruelty in the creation are peripheral questions, superfluous to the issue of whether a creator exists or not. If one can logically establish a creator's existence, subsequent questions about his motives and purposes do not reflect back upon the issue of whether he exists. Similarly, a home may experience famine, poverty, murders, rapes, birth defects, etc., but does the fact that these events have occurred cancel the conclusion that the home was built by a contractor — that the contractor exists? As Wheeler aptly points out, or at least implies, questions about the "morality" of the creation can only be answered through revelation. Regardless of the answers we may come up with, whether they are satisfying or not, or right or wrong, if a creator exists prior to these questions, he exists after them.

R. L. Wysong
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### Re: Snow and Javor: Oxygen and evolution (*Origins* 2:59-63).

In order to bring the *Origins* article up to date, two items need to be mentioned. The present average escape flux of hydrogen from the earth and, therefore, also the oxygen production by the photodissociation of water vapor is now more reliably calculated to be 3 times greater than the estimate cited by G. R. Carruthers 1973 (Brian A. Tinsley, 1975, University of Texas at Dallas, Richardson, Texas, personal communication). Carruthers 1975 (personal communication) pointed out that not much new light could be shed on the origin of atmospheric oxygen based on the *present* escape rate of hydrogen partly because in the past this rate could have been several times greater (Carruthers 1973). The oxygen in the atmosphere of Venus observed by Mariner 10 comes partly from water vapor. Apparently most of it comes from the photodissociation of $CO_2$ which, of course, is still a nonbiological process [Young A, Young L. 1975. Venus. Scientific American 233(3):71-78; Young A. 1975, personal communication; Carruthers 1975, personal communication].

This topic is in a very gaseous state right now and the results of the fall-out of current and continuing research in this area on future evolutionary models is not clear. It is apparent from our correspondence with some of those working in the area of terrestrial and extraterrestrial atmospheric dynamics and from research reports, that the results and implications of some work are not known or ignored by others. We would appreciate critiques and comments on this area of oxygen and evolution.

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**Re: Neufeld: Dinosaur tracks and giant men (*Origins* 2:64-76).**

During the early part of World War II, the Natural Science Foundation of Los Angeles heard rumors of supposed human giant tracks in association with dinosaur tracks along the Paluxy River, near Glen Rose, Texas. A committee of five, including myself, was appointed to investigate the find.

While pursuing this investigation, a Mr. Berry showed us two man-like tracks, about 18 inches in length, and two three-toed *Allosaurous* dinosaur tracks that had been cut from the Cretaceous formation limestone near Glen Rose, Texas.

In the May 1939 issue of *Natural History*, Roland Bird mentions man-like tracks as being "perfect in every detail." Other prominent paleontologists agreed that only man could have made such tracks. When Dr. Bird went to Texas and found these tracks associated with dinosaur tracks, he backed off from his former "human" identification, saying that "no man lived in the age of the dinosaurs."

Because a Mr. Adams of Glen Rose had carved two or three tracks, which were inferior to the actual ones cut from the river bed, it was rumored that *all* the man-like tracks had been carved. The authenticity of the tracks which had been sold to Columbia Union College was questioned. One of these tracks was sectioned to help determine if it was genuine or carved. If the lime mud on which the tracks are to be formed contains discolored streaks of different minerals such as iron, the weight of an animal would depress the coloration. In the case of the Berry tracks, no such iron streaks were present. Since the limestone was quite homogeneous, some have assumed that the tracks were carvings. However, I maintain that negative evidence or lack of evidence should not be used to try to prove a case for carving.

Twice I have examined the sectioned man-like track at Columbia Union College, and I believe that physical evidence stamps the track as genuine and not carved. The evidence has to do with metamorphism. There are many phases of metamorphism, depending on the heat or pressure involved. After wetting the section of the track, I found that the metamorphic phenomenon stood out in stark relief. The normal limestone was discolored with enough iron to give the rock a buff color. The pressure of the foot on the lime mud would have started an incipient type of low-grade metamorphism, causing crystallization into calcite. This process leaves behind chemical impurities, forming white calcite crystals. This phenomenon was observed to be quite prominent in the depression made by the foot. Outside of the foot area the limestone shows the typical buff color.

I have a man track from a tributary canyon south of Glen Rose, and it is similar to the Berry tracks. When my track was sectioned at Loma Linda University, the same phenomena of white calcite crystals showed up, though not quite as prominently as in the case of the Berry tracks.

Dr. George Westcott, an anatomist in Ann Arbor, Michigan, showed me several criteria that in his estimation also stamped my track as being genuine: 1) the one who had cut my track from the limestone had first chiseled a smaller diameter circle, then decided to enlarge the size of the slab, presumably so not to risk breaking the track. 2) I have seen many carved tracks, and all have had flat feet. I have never seen a carving where the carver went to all the trouble to create a high instep. 3) Mud squeezed up higher than the general level between the big toe and the toe next to it. This projection would be more difficult for the carver to produce. When Dr. Mellor, a biologist at the University of Arizona, inspected my man track, he remarked that no such chisel marks were visible. 4) The surface of my track has little holes where pebbles had been removed. One such hole had been flattened by the pressure of the heel, and the mud had been rolled back. 5) Limonite or iron oxide lines, apparently caused by the pressure of the foot, showed up all around the face of the track.

Stanley Taylor of Films for Christ Association spent much time and money excavating along the banks of the river. He found more dinosaur tracks as well as man tracks, and one showed plainly the heel and instep, with the displaced mud around the foot. Taylor also excavated a series of bipedal tracks with a bulldozer. In one instance, an outline of the foot in the limestone beneath was left marked out mainly by white crystallized calcite. This could not be mistaken for anything but a human foot. In the case of freshly excavated tracks, the hue and cry of “carvings” could not apply. The string of tracks was made by a biped, and the five- to six-foot stride matches with the size of the track to indicate a man of perhaps ten feet in height.

Over the years, I have seen along the Paluxy River many man-like tracks and series of bipedal footprints, not now visible. I feel we are wasting too much time on a case so well documented, while we could be inaugurating new projects instead.

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# ARTICLES

## CHEMICAL EVOLUTION

Rene Evard[a]
and
David Schrodetzki[b]

*"Le monde m'embarrasse, et je ne puis pas songer que cette horloge existe et n'a pas d'Horloger"*

*"Nature embarrasses me, and I cannot fathom that this clockwork exists while there is no clock maker."*

Voltaire

### INTRODUCTION TO THE PROBLEM

The chemical investigations that have developed from efforts to support the ideas set forth in Darwin's *The Origin of Species*[1] have given rise to a biochemical hypothesis which attempts to explain the origin of life as an evolutionary progression from simple prebiotic molecules to the complex and integrate biomolecules of today's living organisms. Whether these organisms are as complex as man or as simple as an amoeba, the biochemical evolutionist assumes that both ultimately arose by the transformation of simple molecules into an exceedingly intricate living system. Darwin's theory that phylogeny has increased in complexity over immense periods of time[1] has gained pervasive acceptance. This has produced efforts to demonstrate experimentally that biological compounds could have been formed under prebiotic conditions. Such efforts are based on the assumption that life emerged spontaneously on the surface of the primitive earth after normal chemical processes had brought carbon-containing molecules to a stage of complexity that would make a living organism possible.

The first comprehensive treatments of biochemical evolution were published early in this century by A. I. Oparin[2,4,5] and J. B. S. Haldane.[3] The Oparin-Haldane hypothesis centers around the transformation of single atoms into complex precursors of living systems by means of an intense energy source such as solar ultraviolet radiation or lightning (electrical discharge) in a reducing atmosphere. Such an atmosphere would have been composed of some of the hydrides of elements in the 2nd and 3rd periods of the periodic chart: water ($H_2O$), ammonia ($NH_3$), methane ($CH_4$), hydrogen sulfide ($H_2S$), as well as free hydrogen ($H_2$). Furthermore, Oparin

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**EDITOR'S NOTE: Pagination of the original article was 9-37.**

and Haldane presumed that the nonvolatile precursors diffused into a primitive sea which served as the medium for the transformation of simpler reduced compounds of carbon and other elements into polypeptides and polynucleotides. In their model droplets that had accumulated various organic compounds eventually formed, causing intrasequential reactions spawning a primitive type of natural selection. Only those droplets which could stockpile the raw materials essential for self-perpetuation were allowed to survive.[4] Thus over a period of eons primordial micro-organisms containing many of the biochemical pathways fundamental to life began to flourish.

Direct experimental evidence seeming to validate the Oparin-Haldane hypothesis was first produced in 1953 by S. L. Miller.[6] This led to many other laboratory investigations of the prebiotic precursors that are thought to have occurred on a primitive earth. Based ultimately on the Oparin-Haldane hypothesis, these experiments have served as models depicting the events that are now speculated to have led to the origin of life.

The complex organization of a primordial organism, one which has acquired the most minimal requirements for life, necessitates a wide variety of proteins and nucleic acids. Furthermore, a model for prebiotic formation of these components must be consistent with current geological, biochemical, and astronomical theories.

Before attempting a discussion of experiments dealing with chemical evolution, a brief introduction to some basic biochemical concepts will be helpful. The study of living systems can be divided into descriptive and dynamic aspects: the chemical components themselves, and the reactions taking place in the living cell.

Some of the chemical elements appear to be more “fit” for life: only 27 of the 90 natural chemical elements are essential to living systems. Four elements (carbon, nitrogen, oxygen and hydrogen) make up most of the mass of living cells. All biomolecules, in turn, can be derived from simpler low molecular weight precursors: water, carbon dioxide, atmospheric nitrogen, and possibly ammonia. These precursors can be converted by living cells into larger biomolecules such as amino acids, simple sugars, purines, pyrimidines, glycerol, and fatty acids which, when linked to each other, form the macromolecules of the cell. Thus, proteins are made up of 20 different amino acids linked together. The mononucleotides (made up of either purines or pyrimidine bases, simple sugars, and phosphate) combine to form the nucleic acid. Both proteins and nucleic acids are large biomolecules with molecular weights ranging from about 10,000 to millions.

The next level of organization includes supramolecular structures involving inner cell membranes and complex organelles such as the nucleus, the mitochondria and the ribosomes. Thus a living cell is made up of a wide range of specific compounds as well as highly organized subcellular structural components working together to carry the functions associated with life.

The dynamic aspect is the study of the many reactions taking place simultaneously in a living cell, allowing it to utilize energy in order to grow, develop, differentiate and reproduce. Because these processes all require the continual synthesis and breakdown of a large number of complex chemical entities, they must be under strict control and regulation in order to maintain the normal operation of life within the cell. A living cell is much more than a mixture of chemical compounds placed at random into a small bag; rather, the simplest cell is a highly specific and organized entity possessing tremendous chemical and biological capabilities.

Proteins perform a large number of functions within biological systems, the nature of which depends upon the number and order (sequence) of the amino acids within the molecules. The order is critical. In some instances, having one amino acid out of position will cause a protein to be non-functional. Proteins act as enzymes, which are catalysts involved in all biological reactions; they may serve for storage as a source of amino acids; some are also hormones (messengers) regulating the rate of certain reactions and transmitting messages from one organ to another. All these functions depend upon a specific arrangement of the component amino acids. In addition to chemical functions proteins are an important part of the physical framework of cells and tissues.

Since proteins and nucleic acids make up the most important components of cells, both in terms of function and bulk composition, we shall focus our attention on the experiments dealing with attempts to produce these in the laboratory under presumed prebiotic conditions.

## THE CONDITION OF THE PRIMITIVE ATMOSPHERE

The assumption that the earth's primitive atmosphere predominately contained large amounts of hydrogen (i.e., a reducing environment) is primarily a matter of conjecture.

S. L. Miller in his recent publication[7] states:

> *Arguments concerning the composition of the primitive atmosphere are particularly controversial. It is important, therefore, to state our own prejudice clearly. We believe that there must have been a period when the earth's atmosphere was reducing, because the synthesis of compounds of biological interest takes place only under reducing conditions.*

Under the influence of an intense energy source the reduced gases (i.e. $H_2S$, $H_2$, $CH_4$, $NH_3$, $N_2$, and $H_2O$) are thought to have evolved into the primordial precursors which would result in the development of a living organism. Some indirect evidence does seem to validate such a theory.

When hydrogen was discovered to be the most abundant element in our solar system, it seemed most reasonable to conclude that, "as the Earth was forming, most of its carbon, nitrogen, and oxygen would be in the form of methane, ammonia, and water."[8] However, in the light of current geological and geophysical data, it appears that ammonia on the primitive earth would have been quickly destroyed by ultraviolet radiation.[9] Furthermore, if large amounts of methane had ever been present in the earth's atmosphere, geological evidence for this should also be available. Laboratory experiments show that one consequence of irradiating a dense, highly reducing atmosphere is the production of hydrophobic organic molecules which would be absorbed by sedimentary clays. Consequently, the earliest rocks should contain an unusually large proportion of carbon or organic chemicals. This is not the case.[9]

Abelson[9] and Cloud[10] further state that the primitive atmosphere may have been an oxidizing environment. In other words, the elements of the primitive atmosphere had combined with oxygen as it occurs today. Such an atmosphere would contain oxidized compounds as $CO_2$, $H_2O$, $N_2$, $O_2$, and $SO_2$. However, argumentation for a reducing environment continues relentlessly as scientists today point out that oxygen has a deleterious effect on many aspects of metabolism, because most organic compounds decompose in the presence of free oxygen. The presence of Fe (ferrous iron) in the earlier part of the geological record provides further evidence for a reducing atmosphere. Because ferrous iron is unstable in the presence of $O_2$, it is thought to have existed in an oxygen-free environment.[11] However, even Miller[7] notes that this does not prove a reducing atmosphere. Additional evidence that a reducing atmosphere may not have been present has been given in a previous issue of this journal (see *Origins* 2:59-63).

The arguments for and against a primitive reducing atmosphere may never be adequately resolved. Our view is that scientists may be attempting to fit data into a predetermined mold (i.e. a reducing atmosphere). Arbitrary definition of a system, such as a reducing environment, sets limits to scientific investigation which then becomes bound to the rules of the assumed system. This is not science in its most empirical form.

The most significant source of energy for our planet today, and on a prebiotic earth, is the sun. This solar energy includes ultraviolet radiation and is complemented by lightning (electrical discharge). Laboratory experiments are fashioned primarily around these sources. Other possible sources include volcanoes, shock waves, and radioactive as well as cosmic rays. Thus simulation of a presupposed primitive atmosphere in a given laboratory can become quite involved. Electrical sparks and corona discharges (simulating lightning) as well as x-rays and electron beams (simulating cosmic rays and radioactivity in rock) and heat (simulating the thermal effects of volcanoes), are but a few of the techniques applied to the synthesis of precursors to life as we know it today.

## AMINO ACID SYNTHESIS

Biochemical evolution assumes that laboratory experiments can be used to duplicate primitive-earth events.[3,5] According to Kenyon & Steinman,[12] such experiments may have two possible implications: a) because many approaches result in the same significant products, biochemical evolution took place under several different environments, all of which contributed to the same end, or b) these experiments are mostly only a demonstration of interesting chemical phenomena.

With this latter view a possibility, the biochemical evolutionists must consider carefully data concerning the plausibility of an environment which seems to allow for the transformation of nonliving material into life. Should the evolutionist neglect relevant findings which mitigate against such an environment, one should be skeptical of his conclusions. Again, the proposal that there was a reducing atmosphere on a primitive earth, though not entirely without foundation, has serious problems. As such, one cannot be totally certain that the inferences drawn from data based on this assumption have any bearing on the actual course of chemical evolution.

Assuming that the primitive atmosphere could have been reducing, let us consider the first experiment done in such an environment and carefully review the results. Miller[6,43] working at the University of Chicago in 1953, put the components of a reducing atmosphere (ammonia, methane, hydrogen and water) within an apparatus with a high energy source, in this case, an electrical discharge. This energy source was used since it simulates lightning, which is thought to be an important source of energy on a prebiotic earth. Note the apparatus in Figure 1. The gaseous mixture was admitted to the apparatus and caused to circulate in a clockwise direction when water was heated in the lower sphere. The mixture passed through the electrodes and was liquefied within a condenser below the sparking chamber. The products formed were then washed down into water and captured within a trap.

After one week of sparking, the products were removed from the trap and analyzed by anion-cation-exchange chromatography. The products and yields are summarized in Table 1. The important amino-acid precursors have been underlined.

Since Miller's classic work, several variations of his experiment have been carried out by other researchers using basically the same type of apparatus. Table 2 provides a list of the men and their work, with the analytical results of their products.

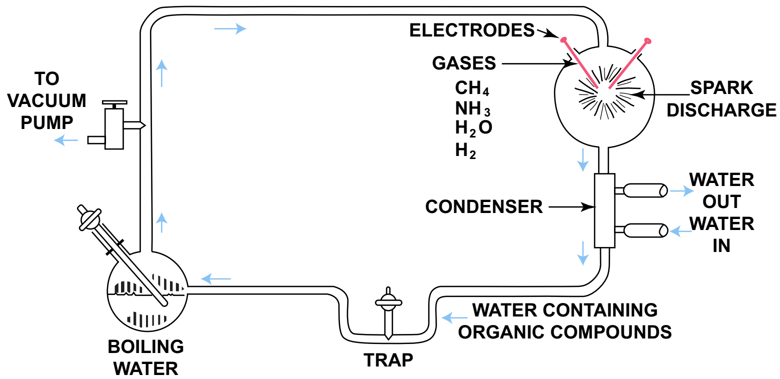


**FIGURE 1. S. L. Miller's apparatus used in his classic experiment.[16]**

## TABLE 1

**Resulting yields after passing $CH_4$, $H_2O$, $NH_3$ and $H_2$ through an electrical discharge. Percent yields based on carbon. Adapted from Reference 7.**

| COMPOUND | % YIELD | COMPOUND | % YIELD |
|---|---|---|---|
| *Glycine* | 2.1 | Iminodiacetic Acid | 0.37 |
| *Alanine* | 1.7 | Succinic Acid | 0.27 |
| β-Alanine | 0.76 | α-Hydroxybutyric Acid | 0.34 |
| *Aspartic Acid* | 0.024 | α-Aminoisobutyric Acid | 0.007 |
| *Glutamic Acid* | 0.051 | α-Amino-N-butyric Acid | 0.34 |
| N-methyl Urea | 0.051 | N-Methylalanine | 0.07 |
| Urea | 0.034 | Propionic Acid | 0.66 |
| Acetic Acid | 0.51 | Sarcosine | 0.25 |
| Formic Acid | 4.0 | Glycolic Acid | 1.9 |
| Iminoaceticpropionic Acid | 0.13 | Latic Acid | 1.6 |

## PROBLEMS WITH AMINO ACID SYNTHESIS

At present, 18 out of the 20 amino acids found in proteins have been synthesized by methods similar to Miller's classic experiment. Tryptophan and glutamine have not been identified among the reaction products. Interestingly enough, two amino acids, tyrosine and phenylalanine, have been produced only on heating mixtures of the presumed prebiotic gases to over 1000ºC.[8] These results are not consistent with the overall evolutionary hypothesis which says that the synthesis must have taken place at temperatures less than 150ºC.[13,14] Also, most amino acids are especially susceptible to decomposition by irreversible decarboxylation caused by heat.[7]

## TABLE 2

**Summary of experiments leading to the formation of amino acids under prebiotic conditions. Abbreviations for the common amino acids: Alanine (ala), Arginine (arg), Aspartic acid (asp), Cysteine (cys), Glutamic acid (glu), Glycine (gly), Histidine (his), Isoleucine (ile), Leucine (leu), Lysine (lys), Methionine (met), Phenylalanine (phe), Proline (pro), Serine (ser), Threonine (thr), Tryptophan (try), Tyrosine (tyr), Valine (val).**

| AUTHOR/REF | CONDITIONS | AMINO ACIDS FORMED | % YIELD |
|---|---|---|---|
| Loeb[44] | CO, $NH_3$, $H_2O$ vapor (electrical discharge) | gly | -------- |
| Baly, Heilbron & Hudson[45] | $H_2CO$, $CO_2$, $H_2O$, nitrite (UV) | positive ninhydrin | -------- |
| Garrison et al.[46] | $CO_2$, $N_2$, $H_2O$ (ionization radiation) | none | -------- |
| Miller[6] | $CH_4$, $NH_3$, $H_2O$, $H^2$ (electrical discharge) | gly, asp, ala | milligrams |
| Bahadur[47] | paraformaldehyde, potassium nitrate (UV) | asn, ser, arg, pro, val, lys, asp | -------- |
| Hough & Rogers[48] | $H_2O$, $N_2$, $CH_4$, $NH_3$ (electrical spark) | ala, gly | milligrams |
| Paschke et al.[49] | ammonia carbonate ($\gamma$ radiation) | gly | -------- |
| Abelson[50] | $CO_2$, $N_2$, $H_2O$ (electrical discharge) | none | -------- |
| Abelson[50] | High conc. $NH_3$ & $CO_2$ with respect to $H_2O$ (electrical discharge) | none | -------- |
| Santamaria & Fleischmann[51] | paraformaldehyde, nitrate (UV) | lys, asn, val, ala, pro, asp | -------- |
| Bahadur et al.[52] | paraformaldehyde, $H_2O$ atmospheric $NO_2$ (UV) | gly, ala, val, his, glu, asp | -------- |
| Deschreider[53] | mono or dicarb acids, ammonium salts (UV) | asp, ala, gly | -------- |
| Reid[54] | $H_2NOH$, $H_2CO$, $CO_2$ (UV) | gly, ala | 0.03% for gly |
| Pavlovskaya & Pasynskii[55] | $H_2O$, $H_2CO$, $NH_4NO_3$ at 40-45º C (irradiation) | ser, gly, glu, ala, val | -------- |
| Pavlovskaya & Pasynskii[55] | $H_2O$, $H_2CO$, $NH_4Cl$ at 40-45º C (irradiation) | ser, gly, glu, ala, val, phe | -------- |
| Pavlovskaya & Pasynskii[55] | $H_2O$, $H_2CO$, $NH_4NO_3$ at 1-2º C (irradiation) | glu, ala, val, phe, ser, gly, ile | -------- |
| Pavlovskaya & Pasynskii[55] | $H_2O$, $H_2CO$, $NH_4NO_3$ or $NH_4Cl$ + chalk, pH 6.0 (irradiation) | glu, ala, val, phe | $10^{-4}$M |
| Pavlovskaya & Pasynskii[55] | $CH_4$,$NH_3$, CO, $H_2O$ (electrical discharge) | gly, ala, asp, glu | -------- |
| Oro et al.[56] | $H_2NOH$, hydroxyamine (100ºC) | gly, ala, asp, ser, thr | -------- |
| Fox[57] | glucose, urea at 150-200ºC (hydrolysis) | gly | -------- |
| Fox[57] | malic acid, urea at 150-200ºC (hydrolysis) | asp | -------- |
| Fox[57] | hydroxyglutamic acid, $NH_3$ at 150-200ºC | glu | -------- |
| Lu et al.[58] | $H_2$, $CH_4$, $NH_3$, $H2_S$, $H_2O$ vapor (electrical discharge) | cys, cystine, met? | -------- |

## TABLE 2 (continued)

| AUTHOR/REF | CONDITIONS | AMINO ACIDS FORMED | % YIELD |
|---|---|---|---|
| Oro & Kamat[59] | HCN, $NH_3OH$, $H_2O$, heat (hydrolysis) | ala, gly, asp | -------- |
| Oro[60] | $CH_4$, $NH_3$, $H_2O$ (ionizing radiation) | gly, ala, asp | -------- |
| Skewes & Oro[60] | $CH_4$, $NH_3$, $H_2O$,1300ºK | gly, ala, asp, thr, ser, glu, ile, leu, tyr, phe | -------- |
| Grassenbacher & Knight[60] | $NH_3$, $H_2O$, $CH_4$, $H_2$ (electrical spark) | asp, thr, ser, glu,gly, ala, ile, leu | *2,4,14,1,16,14,2,2,4 |
| Palm & Calvin[61] | $CH_4$, $NH_3$, $H_2$, $H_2O$ (irradiation) | gly, ala, asp | .04%, .18%, 0.4% |
| Lowe et al.[62] | oxalic acid, hydrocyanic acid, $H_2O$, $NH_3$ (hydrolysis) heat | asp, thr, ser, glu, gly, ala, ile, leu | $^+$576, 3, 832, 13, 11420, 316, 8, 8 |
| Oro[64] | $CH_4$, $C_2H_6$, $NH_4OH$ (electrical discharge) | gly, ala, asp, asn, ile, pro | -------- |
| Steinman & Lillevik[64] | acetic acid, $N_2$, $O_2$ (electrical discharge) | gly, asp | -------- |
| Steinman & Lillevik[64] | glycerol, $N_2$, $O_2$ (electrical discharge) | positive ninhydrin | 3.4% of mixture |
| Harada & Fox[65] | $CH_4$, $NH_3OH$, 1050ºC | asp, thr, ser, glu, pro, gly, ala, val, ile, leu, tyr, phe | 15.2%, 3%, 10%, 10.2%, 12.3%, 24.4%, 20.2%, 2.1%, 2.5%, 4.6%, 2.0%, 6.2% |
| Kolomiychenko[66] | various organic mixtures (IR, visible and UV light source) | as many as 10 AA (see ref) | -------- |
| Matthews & Moser[67] | $CH_4$, $NH_3$ (electrical discharge) | lys, his, asp, thr, ser, gly, ala, ile | $^+$13, 13, 24, 15, 22, 589, 5,6 |
| Matthews & Moser[67] | HCN, $NH_3$ (hydrolysis) | lys, his, asp, thr, ser, gly, ile | $^+$trace, 16, 30, 17, 14, 165, 0.6 |
| Abelson[9] | $N_2$, $H_2$, CO (radiation) | none | -------- |
| Sanchez et al.[41] | $N_2$, $CH_4$, cyanoacetylene (electrical discharge) | asn, asp | -------- |
| Choughuley & Lemmon[68] | $H_2S$, $NH_4OH$, $CH_4$ (irradiation $e^-$ beam) | cysteic acid | .01% |
| Matthews & Moser[69] | NCH, $NH_3$, heat (hydrolysis) | lys, his, arg, asp, thr, ser, glu, gly, ala, val, ile, leu | $^+$3, 5, 7, 27, 1, 5, .9, 480, 12, .2, .7, .7 |
| Harada[70] | $H_2CO$, $N_2$, 23ºC (hydrolysis) | gly, ala, asp, thr, ser, leu, val | -------- |
| Hasselstrom et al.[71] | $NH_4$Acetate, $H_2O$ ($e^-$ beam) | gly, asp | -------- |
| Dose & Ponnamperma[72] | N-acetyl-glycine (irradiation, $\gamma$ ) | asp thr | -------- |
| Moser et al.[73] | $H_2O$, diaminomaleonitrile, 160ºC | lys, thr, arg, asp, his, ser, glu, gly, ala, val, ile, leu | $^+$4, 3, 0.2, 32, 3, 14, 1, 2093, 14, .6, .2, .6 |
| Moser & Matthews[74] | aminoacetonitrile (hydrolysis) | lys, asp, thr, ser, glu, gly, ala | $^+$7, 114, 4, 6, 9, 1283, 11 |
| Steinman et al.[75] | $NH_4CNS$ (UV irradiation) | met | less than 1% |
| Friedmann & Miller[76] | $CH_4$, $C_2H_6$, $C_2H_2$ (UV, hot wire, spark) | phe, tyr | 4.7%, .003% |
| Friedmann & Miller[77] | HCN, $NH_3$, heat (hydrolysis) | val, leu, ile? | less than $10^{-6}$% |
| Bar-Nun et al.[78] | $H_2O$, $CH_4$, $C_2H_6$, $NH_3$, AR (shock waves) | gly, ala, val, leu | -------- |

## TABLE 2 (continued)

| AUTHOR/REF | CONDITIONS | AMINO ACIDS FORMED | % YIELD |
|---|---|---|---|
| Fox et al.[79] | lunar samples (acid hydrolysis) | gly, ala, ser, asp, thr | -------- |
| Nagy et al.[80] | lunar extracts | gly, ala | -------- |
| Fox & Windsor[81] | $H_2CO$, $NH_3$, heat | asp, ser, glu, pro, gly, ala, val, ile, leu, phe | -------- |
| Khare & Sagen[82] | $CH_4$, $C_2H_6$, $NH_3$, $H_2S$ (UV irradiation) | asp, ser, glu, pro, gly, ala, val, ile, leu, phe | .002 to .007% |
| Sagen & Khare[83] | $H_2S$, $H_2O$, $NH_3$, $C_2H_6$ (UV) | ala, gly, cys, ser, glu, asp | +597, 56, 25.7, 6.1, 6.1, 3.06 |
| Trump & Miller[84] | $CH_4$, $N_2$, $H_2S$, $H_2O$, $NH_3$ (electrical discharge) | met, gly, ala | 0.3%, .068%, .010% |
| Ring et al.[15] | $CH_4$, $N_2$, $NH_3$, $H_2O$ (electrical discharge) | gly, ala, val, leu, ile | total yield 1.55% |
| Ferris et al.[85] | HCN, $H_2O$, $NH_4OH$ (acid hydrolysis) | asp, thr, ser, glu, gly, ala, val, ile, leu, lys, his | #.020, .019, .001, .009, .591, .005, .001, trace, .004, .001, trace |
| Ferris et al.[86] | HCN, $H_2O$, basic solution (acid hydrolysis) | asp, thr, ser, gly, ala, val, ile, leu, lys, his | results vary depending on added base of chemical species |
| Lawless & Boynton[19] | $CH_4$, $H_2O$, $NH_3$, 900-1060ºC | mostly beta AAs | .007% |
| Harada & Iwasaki[87] | aliphatic dicarb acids, heat $NH_3$, $H_2O$ (glow discharge) | asp, gly, ala | 4.5 - .03% |
| Ferris et al.[88] | hydrolysis of HCN, oligomer | gly, asp, ala, ile | -------- |

*relative molar proportions
+mole/gram of hydrolyzate
#mole/mg applied sample

Richard Lemmon[8] notes that there is an intrinsic need for controls to eliminate the presence of bacteria and other contamination in experiments dealing with the synthesis of amino acids. This point seems very valid, for amino acids present within various types of bacteria caught in the experimental apparatus may be picked up by any number of methods used in identifying amino acids. Notwithstanding, the only reliable methods employed for the identification of amino acids to date are the mixed melting-point derivatives or an analysis by gas chromatography and by a mass spectrometry.[15] As Miller[15] states:

> *The correct elution time on the amino acid analyzer is insufficient by itself to identify an amino acid. Many amino acids not found in proteins have*

*peaks that coincide with protein amino acids. These same limiting factors are true for gas chromatography, or electrophoresis, even with different solvents.*

This information gives some grasp of the difficulties encountered and the reliability of amino acid identification.

Turning to the problems of the actual synthesis of amino acids, one must note the thermodynamic stability of the products formed in the reducing atmosphere that produced them. Simply stated, the reactions that create the amino acids also tend to destroy them.[9,16] This is due in part to the strength of the energy source. One feature of Miller's apparatus and subsequent variations of his experiment is a trap suitable for the storage and/or the immediate removal of the products of the reaction.[12] Thus, one must propose the existence of a primitive trap[24] on earth during the early phases of the chemical evolutionary process. Without such, the destructive forces of electrical discharges or ultraviolet radiation would destroy the prebiotic precursors of life that they had produced. A primitive-earth trap has been suggested by Bernal;[17] however, it seems precluded by Hull.[18]

Considering the thermodynamics of chemical evolution, especially the equilibrium concentrations of synthesized organic compounds, Hull demonstrated that the accumulation of amino acids on a primitive earth would result in a concentration hopelessly low and totally unsuitable as a starting material.[18] Calculating not only the relative rates of formation of several amino acids, but also the rates of their decomposition, Hull found the resultant concentrations to be on the order of $10^{-12}$ moles/liter or less. For instance, in calculations concerning glycine, the simplest amino acid, the mean concentration would be between $10^{-12}$ and $10^{-27}$ m/l, far below the $10^{-2}$ molar concentrations thought to be necessary for the chemical evolutionary development of life.[8] As other organic compounds are considered, the concentrations become even smaller (glucose $10^{-134}$ m/l).[18] Quoting Hull:

*The conclusion from the arguments presents the most serious obstacle.... First, thermodynamic calculations predict vanishingly small concentrations of even the simplest organic compounds. Secondly, the reactions that are involved to synthesize such compounds are seen to be much more effective in decomposing them.*[18]

The yields of key amino acids such as aspartic and glutamic acids (Table 2) are very low and not at all in proportion to the biological system concentrations. The total yield of these two compounds is less than 0.07%, while other important amino acids are not even present under the conditions producing these. One should keep these particular amino acids in mind, because they are very significant when one speculates on mechanisms for the polymerization of amino acids into polypeptides.

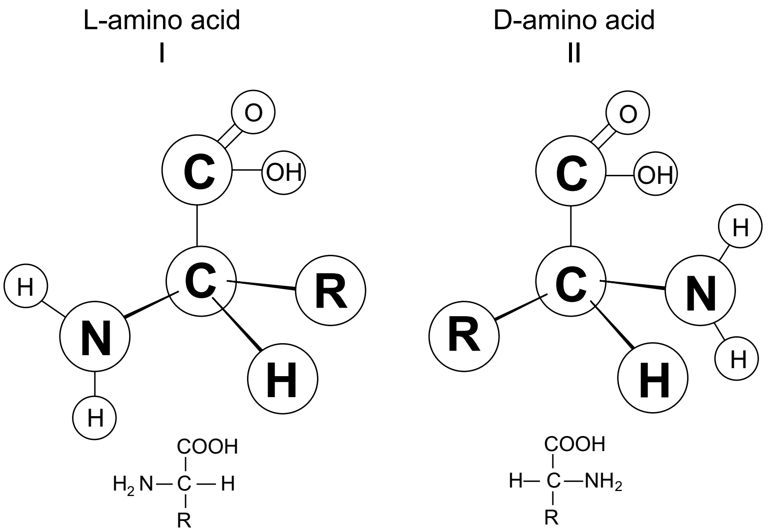


**FIGURE 2. Optical isomers (D- and L-forms) of an amino acid. Note that one form is a mirror image of the other.**

## STEREOCHEMISTRY

Stereochemistry deals with the three-dimensional structure of chemical compounds. Nearly all organic molecules, especially the amino acids and sugars, may exist in more than one three-dimensional arrangement. For instance, amino acids found in proteins have the amino group located at the a-carbon (next to the carboxyl group) on the carbon skeleton. While biological systems do utilize amino acids that have other types of structure, only the alpha type are found in proteins.

In addition, alpha amino acids themselves may exist in two different forms: the D- and the L-configurations. These are called optical isomers (see Figure 2). Optical isomers have the same relationship as the right and left hand of a person. Possessing identical chemical properties, they differ in one physical property: the behavior under the influence of polarized light. Proteins fundamental to the maintenance of living systems are composed exclusively of L-amino acids. This configuration is required in order for the particular protein molecule to attain the shape that is critical for its biological function.

A principle of organic chemical synthesis is that reactions starting with an optically inactive mixture of reactants will yield an optically inactive product. This is the case when amino acids are synthesized from simple organic molecules. The amino acids formed are a mixture of equal amounts

**TABLE 3**

**Speculations on the origin of optical activity.**

| MEANS | REFERENCE |
|---|---|
| Formation on quartz crystals | - Wald[29], Seifert[31] |
| Photochemical reaction, (circularly polarized light) | - Wald[29], Kuhn et al.[30] |
| Selection of a-helix in proteins | - Wald[29], Blout[32], Idelson & Blout[33] |
| Asymmetric polymerization | - Steinman[34], Kovacs[35] |
| Separation by the wind | - Northrup[36] |
| Beta emission | - Garay[89] |

of the D- and L-forms, yet biological systems have the unique ability to incorporate only the L-form into proteins and completely exclude the D-form. This critical point in the problem of chemical evolution has not been resolved satisfactorily.

Amino acids produced under prebiotic conditions designated would more than likely contain equal parts of the D- and L-isomers (a racemic mixture).[12] As noted, those amino acids found in living systems are of the L-α-configuration. Thus any hypothesis dealing with chemical evolution must ultimately account for the incorporation of the specific L-α-configuration over the other alternatives. Indeed, there have been many attempts to account for the origin of such specific optically active compounds within living organisms (see Table 3).

The proposal that the stereohomogenity of the biologically active amino acids has come about through polymerization on the surface of optically active quartz is no longer accepted.[29,31] When quartz is used to orient the amino acids into specific configurations, D- and L-amino acids are selected to the same degree.[31] As for the possibility of the stereochemical phenomenon occurring from circular polarized light and the resultant reactions, very little rotation within the acids is found.[12,29,30] Furthermore, this assumption is not sound on theoretical grounds, because D-amino acids do not necessarily rotate the plane of polarized light to the right, and L-amino acids do not always rotate the plane to the left. Therefore, if circular polarized light was used to induce asymmetric synthesis, it would produce both D- and L-amino acids.

The selection of L-α-conformation did not occur as a result of the specificity of the α-helix for L-amino acids, as it has been found that limited regions of an α-helix of either polarity could be formed in a racemic mixture of amino acids.[7,12,29,32,33] Worthy of note also is the fact that asymmetric polymerization has been found to produce a certain degree of racemization among amino acids.[12,34,35] Finally, Northrup's proposal[36] that separation could have occurred by the natural forces of the wind, after the drying of a mixture of D- and, L-amino acids, seems totally preposterous.

Experiments performed by Lawless[19] yielded a predominance of the beta-amino acids, rather than the alpha form. He suggests:

> *The formation of a primitive organism in an environment requiring the utilization of beta-amino acids, followed by the evolution of an organism that utilizes alpha amino acids is...unattractive.*

All biological systems have the unique ability to differentiate between stereoisomers. This unique stereochemistry is required at the molecular level so that larger molecules will have the proper shape allowing them to carry out their varied and specific functions within the living cell. This shape is again important in determining the activity and the proper functioning of subcellular structures of the cell. There is a definite order and organization associated with living systems, and the stereochemistry of the basic building blocks is one of the key components of this beautiful structure.

## POLYMERIZATION

Polymerization is the joining of molecular subunits which form protein, nucleic acids and other complex molecules in biological systems. Such a process not only involves the formation of chemical bonds and the elimination of water, but the specific sequence or linear arrangement of the subunits is what causes these molecules to be biologically active. The specific activity of each biochemical reaction is due to the specific arrangement of amino acids in proteins, or nucleotides in nucleic acid (the backbone of the gene structures). The displacement of a single amino acid or nucleotide may alter the biochemical function of a polymer. This alteration may be so crucial that its ultimate effect could be death to the organism.

The polymerization of biomolecules involves reversing a thermodynamic barrier, an energy barrier which does not allow monomers (the molecular subunits) to spontaneously combine to form polymers unless they have been activated or energy is supplied.

Several mechanisms for such polymerization have been proposed. After Hull stated that the concentration of the prebiotic precursors in the oceans would never have reached an appreciable level for self-polymerization, researchers have sought other devices. One envisioned by S. W. Fox and others[20,21,22] involves the use of a dry, pure mixture of amino acids and high concentrations of glutamic and aspartic acids, while employing thermal (heat) activation as an energy source. Heating the mixture at 175ºC for 2 to 3 hours converts about 13% of it to a water-soluble polymer, made up of many kinds of amino acids.[22] When dissolved in hot water and allowed to cool, the polymer precipitates, forming spherical globules said by Fox to resemble coccoid bacteria, the so-called "proteinoids."[23,24]

Such may be the case; however, one must note: a) if this mixture were heated for more than several hours, the polymers would have been destroyed (on a prebiotic earth the mixture would have been heated for a considerable length of time, and thus easily destroyed), and b) high concentrations of glutamic and aspartic acids were used, while the results of experiments dealing with the synthesis of these acids yielded less than 0.07%. In reference to a) cited above, it is also difficult to conceive of a primitive-earth environment that would allow a mixture of amino acids, high in purity, dry, rich in glutamic and aspartic acid, to react at 175ºC for no more than 6 hours, then cool, allowing for polymerization.

To compound the problem, the polymerization of amino acids by heating shows a marked degree of racemization of the optically active starting reagents,[20] and stereoselective catalysts and surfaces would be nonexistent on a prebiotic earth.[12]

Investigators have discovered several means of enhancing the yields of many polymerization reactions through the use of acids, a process known as chemical activation. The presence of phosphoric or polyphosphoric acid nearly doubles the typical yield.[20,25,26] Also, it has been demonstrated that peptide bonds between amino acids may be promoted by cyanamides in acidic solutions.[27,28] While these facts seem to present a more realistic solution in terms of increasing the yield in a primitive ocean, these compounds are either acidic themselves or in acidic solution. As such the primitive pH of the ocean, calculated to be 8.0-8.1,[7] would be lowered, thus making the seas an environment unsuited for chemical evolution. Since many organic compounds are unstable and dissociate below a pH of 7, it is doubtful that the addition of acid solution naturally would enhance the chance of survival of a primitive organism should it have evolved. Similarly, histidine (an amino acid) is found to be relatively unstable, particularly to acid hydrolysis.[7] Another unattractive feature is that polymerization with dilute cynanamide solutions yields short polypeptides.[12] No mechanism is yet available to explain the synthesis of larger molecules, except by saying that, "in time," such a phenomenon could have occurred.

Because the sequence specificity in proteins is so important, one must ask how such could have arisen abiologically, and if so, by what processes and constraints. As the number and different kinds of amino acids within a single polymer increase, so does the number of possible sequence structures[16] (see Table 4). Recall that a polypeptide can exist in any combi-

### TABLE 4

**Total number of possible sequence isomers per number of amino acids.[16]**

| NUMBER OF DIFFERENT AMINO ACIDS IN THE POLYMER | NUMBER OF ISOMERS |
|---|---|
| 2 | 2 |
| 3 | 6 |
| 4 | 24 |
| 5 | 120 |
| 6 | 720 |
| 8 | 40,320 |
| 10 | 3,628,800 |
| 17 | $3\times10^{14}$ |

nation of 20 different kinds of L-α-amino acids. Should the formation of polymers have been a random event, the existence of a single molecule of every possible sequence of a polymer (isomers) with only 12 amino acid kinds would result in a total mass that would equal $10^{280}$ grams (1 followed by 280 zeros)[37] (see Table 5). Hence the chance of obtaining a specific polymer by random events seems hopelessly low.

### TABLE 5

**Summary of the isomers of a polymer consisting of 12 amino acids.[37]**

Molecular weight: 34,000

Total number of different amino acids: 12

Total number of residues (amino acids in polymer): 288

Total number of possible sequences: $10^{300}$ isomers

If only one molecule of each isomer existed on earth, the total mass would be $10^{280}$ grams.

Whereas the total mass of the earth is but $10^{27}$ grams.

In view of this consideration, the firm establishment of a mechanism for the polymerization of the amino acids produced under presupposed abiotic conditions is very difficult to formulate. Though such a process cannot be looked upon as totally impossible, it is clearly not an adequate basis for explaining the emergence of life as we know it today. Therefore we must seek new vistas of understanding, or perhaps the rebirth of more plausible ideas.

## NUCLEIC ACID SYNTHESIS

Nucleic acids are another key component of biological systems. As we have mentioned previously, nucleic acids are made up of: a) five

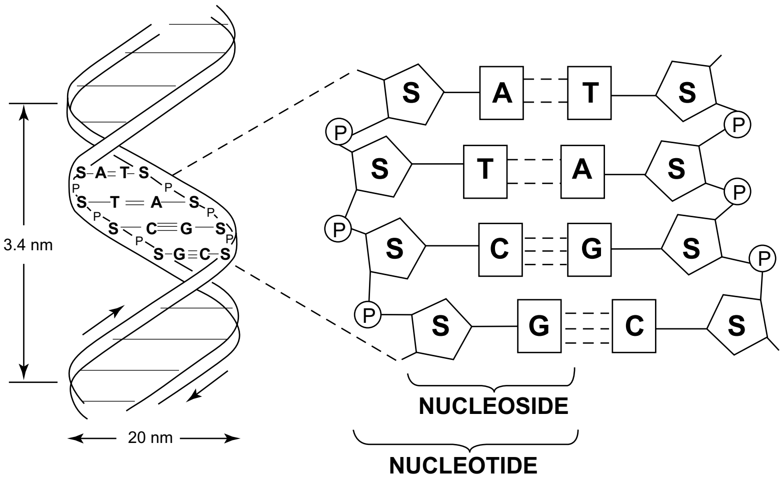


**FIGURE 3. Schematic representation of the structure of DNA.**

**A. The double helix of DNA.**
**B. The backbone of the two strands of DNA. A,T,G,C represent the bases adenine, thyamine, guanine, and cytosine respectively. S represents the sugar deoxyribose, and P is the phosphate. The two strands are joined through hydrogen bonding (dashed lines) formed between certain bases.**

organic bases (adenine, guanine, uracil, cytosine, thyamine), b) two sugars (ribose or deoxyribose), and c) phosphoric acid (Figure 3). The basic unit of the nucleic acid is the nucleotide, a composite structure consisting of these three components. When properly linked in a sequence, the nucleotides form either deoxyribonucleic acid (DNA) or ribonucleic acid (RNA), depending on the nature of the sugar present.

To produce nucleic acids, one must first account for the formation of their building blocks, the purines and pyrimidine bases, both ribose and deoxyribose sugars, as well as the incorporation of inorganic phosphate into these organic molecules.

Oro & Kimball synthesized a purine base, adenine, by condensing hydrogen cyanide in a concentrated ammonia solution (1-10 M).[38] However, the yield was extremely low (less than 5%), leaving one to speculate on how a concentration of adenine could be built up sufficiently to spontaneously coalesce with the other nucleotide components in a vast aqueous environment, the prebiotic sea. Also, the above experimental situation was rather drastic, since no one yet has explained the presence of such high concentrations of ammonia on a prebiotic earth. Orgel & Lohrmann under-took the study of a related synthesis of adenine in more dilute solutions, as they saw Oro's work was not realistic in terms of reasonable prebiotic conditions.[42] Orgel states that if all the nitrogen in the atmosphere was converted to ammonium cyanide and dissolved in the oceans, the resulting solutions would not exceed 0.2 M in concentration. Because hydrogen cyanide is rapidly converted to formate, it is unlikely that the cyanide concentration in the oceans ever exceeded $10^{-4}$ M.[42] To further complicate matters, hydrolysis of cyanide to foramide and formic acid becomes the dominant reaction for cyanide once its concentration drops below 0.01 M.[7]

Several researchers believe a more plausible explanation exists for the formation of concentrated cyanide, thus enabling the formation of adenine in appreciable yields. When the very dilute ammonium cyanide solution is cooled to temperatures below 0ºC (-10 to -22ºC), ice separates out, and a concentrated solution of $NH_4CH$ is obtained. At this eutectic temperature, the liquid phase contains about 75% hydrogen cyanide. In this way, excellent yields have been produced from dilute (0.001 M) cyanide solutions kept at -10ºC.[7,50] However, Miller notes "that the presence of large amounts of salt greatly lowers the efficiency of cyanide polymerization in eutectics, since the eutectic volume is determined by the amount of salt present rather than cyanide."[7] It is thought that such a synthesis and subsequent cyanide polymerization occurred on the frozen surfaces of lakes or oceans. This restricts the prebiotic milieu having the necessary conditions for the condensing of the nitrogen bases, sugars, and phosphate to form nucleotides.

Guanine, the other purine, has to be synthesized by the reactions of cyanate, urea or cyanogen. Its synthesis has not been studied in as much detail as that of adenine.[7]

As for the synthesis of pyrimidines, Ferris et al. have reported the production of uracil through a cytosine synthesis.[39] Cytosine hydrolyzes quite easily to uracil, one of the three pyrimidines. Cyanate and cyanoacetylene are also used to synthesize cytosine.[7] However, these compounds are highly unstable. Ferris also states that "the instability of cyanate and cyanoacetylene restricts severely the range of prebiotic environments in which such a synthesis could have occurred."[39] Further complications arise because the half-life of cyanoacetylene is at most a few hundred years. Similarly, under any conditions, cyanate hydrolysis to ammonium carbonate takes place in less than one hundred years.[7,40] Thus it is difficult to comprehend how the necessary high concentrations could have accumulated in a primitive ocean. It is speculated that cyanate could have been concentrated somewhat during the evaporation of pools and then reacted with cyanoacetylene from the atmosphere. This is not very convincing, because cyanoacetylene is destroyed rapidly in the presence of ammonia, thus complicating the simultaneous synthesis of purines.[41]

## SUGARS AND PHOSPHORYLATION

The prebiotic production of pentose sugars (part of the nucleotides) has also been investigated. In the mid-nineteenth century, Butlerow[7] observed that in strongly alkaline solutions, formaldehyde would condense, forming sugar-like molecules. Should sodium hydroxide, as the strong alkali, be mixed with formaldehyde, the Cannizzaro reaction occurs, but it does not give appreciable amounts of sugar.

There are problems with the synthesis of these sugars. As the reaction proceeds, the earliest product identifiable is glycolaldehyde, followed by glyceraldehyde, dihydroxyacetone, tetrose, pentose and hexose sugars including ribose. Yields must have been upwards of 50%; however, to get such yields, the reactions must be stopped completely at the appropriate moment.[7] The first question raised is how those sugars employed by the evolving system were preferred over the other sugars synthesized. This choosing process must be very specific, because a multitude of isomers would be found after such a synthesis. No answer to this problem has as yet been proposed. Unstable in aqueous solutions, especially above pH 7, sugars are destroyed under the conditions of the Butlerow reaction soon after they are formed.[7] Another difficulty is that the mixtures obtained by the sugars yield only a very small proportion of ribose. Finally, this reaction does not occur with formaldehyde concentrations below 0.01 M. Thus, one must again present an additional model showing that the formaldehyde concentration either rose above 0.01 M or that lower formaldehyde concentrations are capable of producing sugars in a primitive sea.[7]

Most workers in this field simply take for granted the actual synthesis of ribose under prebiotic conditions. Nevertheless this is a key component of the very fundamental nucleic acid molecule.

The third component of nucleic acids is phosphate. A number of mechanisms have been proposed for the phosphorylation of nucleosides. In one such experiment, the nucleoside uridine was heated with the inorganic phosphate $Ca(H_2PO_4)_2$ at 65ºC for nine months.[42] Uridine monophosphates along with small amounts of uridine diphosphates were produced. However, $Ca(H_2PO_4)_2$ is precipitated only from acid solutions and it seems unlikely to have ever been a common mineral, especially in a reducing primitive environment.[48] One of the largest obstacles to overcome is that, at present, no experiments have been performed that satisfactorily show the incorporation of inorganic phosphate into an organic molecule under prebiotic conditions.[7] Nor has the next step (nucleotide polymerization) yet been positively demonstrated in the laboratory. In the words of

Miller, "The origin of nucleosides and nucleotides remains...one of the major problems in prebiotic synthesis."[7]

## CONCLUSIONS

In this article we have attempted to critically analyze the results of laboratory experiments designed to demonstrate that life could have originated on this planet spontaneously.

While some data seems to support the hypothesis that the primitive atmosphere was reducing, evidence to the contrary must not be neglected. A problem in the deliberation over a reducing atmosphere compared to an oxidizing one lies in the way carbon appeared on the surface of the prebiotic earth. Should it have been outgased from the prebiotic earth as $CH_4$, one would encounter a reducing milieu. If it was outgased as $CO_2$, a potentially oxidizing atmosphere would be formed. It would seem that the only certainty as to the kind of environment that existed on a hypothetical primitive earth remains with the prejudice of the individual investigators.

Are there positive results from the standpoint of biochemical evolution?

Eighteen out of twenty amino acids have been produced under what is believed to have been the prebiotic conditions of the earth. Under specific conditions, researchers have also found that protein-like substances, the so-called "proteinoids," have been produced. Likewise, four or five bases of nucleic acids have been synthesized, though phosphorylation of these components has been very difficult.

In Table 2, we have shown that 18 of the 20 amino acids can be synthesized from several different types of starting materials and energy sources. Though not specifically noted in the table, the molar yields vary dramatically when one compares the starting materials of the various experiments. Abelson found that when high proportions of methane and ammonia were mixed with water vapor and treated in an apparatus similar to Miller's, no amino acids were produced.

In comparing the various problems of a prebiotic synthesis, an innate difficulty becomes apparent. Simply stated, the different conditions under which the various components of a living system are first thought to have arisen are in conflict with each other. Many diverse environments had to exist independently while allowing the products to be mutually dependent on one another, the resultants then coalescing and ultimately creating a living cell. This may be an understatement of the problem. One laboratory procedure for synthesizing prebiotic compounds will use one molar ratio of reactants while these will be varied for other procedures. Still others use dry concentrated reactants. Concentrating raw amino acids into compounds similar in purity to those used in the laboratory poses a further dilemma to the biochemical evolutionist. One environment, while capable of creating some of the amino acids and cellular building blocks, ultimately destroys many of the other components needed for the assemblage of a living cell. For instance, sugars are destroyed in an alkaline environment, the prominent environment in which the amino acids are produced. While some investigators assume basic conditions that are necessary for their synthesis of fundamental biological compounds, others employ acidic conditions. Also researchers have, at times, used different temperatures during the course of their reactions. Thus it becomes necessary to propose a highly complex and implausible model of the primitive earth.

To complicate matters further, one must account for the optical activity of all biological compounds; namely, the presence of L-α-amino acids and D-nucleosides. Present researchers believe this specificity to be purely accidental.[7] A valid reason for the choice of one configuration over another has not yet been found. If the choice of the optical specificity of the amino acids and nucleosides is considered to be accidental, one must still be able to account for the incorporation into proteins of one kind of amino acid in preference to another.

Polymerization reactions present several problems. While they require unusually high concentrations of amino acids, the yields have been very low. It is difficult to conceive of a primitive-earth environment which would produce pure mixtures of amino acids rich in glutamic and aspartic acids as proposed. Secondly, polymerization only succeeds when mixtures are heated for short periods of time. Rapid cooling would be necessary. Other conditions do not produce proteinoids.

As for the synthesis of nucleic acids, phosphorylation and the subsequent formation of sugars, one major difficulty has not been previously stated. In the presence of ammonia (which is considered to have been a constituent of a reducing atmosphere), formaldehyde together with hydrogen cyanide forms glycine rather than condensing to produce a sugar. In effect, no sugars are formed.

In retrospect, those who investigate the origins of life in an evolutionary context should be asked to turn to new vistas, not in terms of men and machines, but to something beyond the understanding of life in chemical terms. Biochemical evolution is a feeble attempt at explaining the origin of life. From a scientific standpoint, this explanation leaves a large number of unanswered questions.

> *The fact that a chemist can carry out an organic synthesis in the laboratory does not prove that the same synthesis will occur in the atmosphere or open sea without the chemist. The second law of thermodynamics applies not only to inorganic gases in the atmosphere but also to organic compounds in the ocean. Living cells may reverse the process, but in the absence of life, 'die Entropie der Welt stebt einem Maximum zu.'*[18]

As mentioned above, the experimental facts and accomplishments are at best minimal. Even if pure L-amino acids could have been synthesized, and even if they were polymerized into polypeptides of specific sequences, this still would be a long way from having all the proteins present in a single living cell. The same problem exists with the formation of nucleic acids, in which thousands of nucleotides must be joined in a very specific sequence; yet only dinucleotides have been formed under prebiotic conditions.

But even if proteins and nucleic acids could have been unequivocally synthesized by these experiments, their existence does not constitute a living system. A simple cell is an exceedingly complex ordered system. It has an amazing amount of information stored into its nucleus, information that determines the structure and function of the cell. It can reproduce itself, forming an identical twin, or it can differentiate. It has the ability to utilize and transform energy as well as store it for later use. All of these functions require a complex network of various integrated pathways involving a considerable number of chemical reactions, each one catalyzed by a specific enzyme. All the steps are carefully controlled by remarkable feedback mechanisms reminiscent of the operation of computers.

In the final analysis, the entire range of chemical evolution is one for which the following statement by Kerkut is particularly fitting:

> *It is very depressing to find that many subjects are becoming encased in scientific dogmatism. The basic information is frequently overlooked or ignored and opinions become repeated so often and so loudly that they take on the tone of laws. Although it does take a considerable amount of time, it is essential that the basic information is frequently re-examined and the conclusion analyzed. From time to time, one must stop and attempt to think things out for oneself instead of just accepting the most widely quoted viewpoint.*[90]

This is what we have attempted to accomplish in this study. We have tried to carefully examine the scientific data presented in the literature dealing with chemical evolution and critically evaluate the results to determine if the conclusions of the investigators are sound. Such a study reveals that chemical evolution does not provide a satisfying solution to the question of the origin of life.

## REFERENCES


1. Darwin C. 1890. The origin of species by means of natural selection. 6th reprint. NY: D. Appleton and Co.
2. (a) Oparin AI. 1924. Proischogdenie Zhizni. Moscow: Moscovsky Rabotchii. (b) Oparin AI. 1938. The origin of life. NY: Macmillan Company.
3. (a) Haldane JBS. 1929. Rationalist Annual 148:3; (b) Haldane JBS. 1933. Science and human life. NY: Harper Brothers, p 148.

4. Oparin AI. 1957. The origin of life on earth. NY: Academic Press.
5. Oparin AI. 1953. The origin of life. 2nd English edition. NY: Dover Publications, p 101.
6. Miller SL. 1953. A production of amino acids under possible primitive earth conditions. Science 117:528-529.
7. Miller SL, Orgel LE. 1974. The origins of life on the earth. Englewood Cliffs, NJ: Prentice-Hall.
8. Lemmon RM. 1970. Chemical evolution. Chemical Reviews 70:95.
9. Abelson PH. 1966. Chemical events on the primitive earth. Proceedings of the National Academy of Sciences (USA) 55:1365-1372.
10. Cloud PE, Jr. 1968. Atmospheric and hydrospheric evolution on the primitive earth. Science 160:729.
11. Rutten MG. 1962. The geological aspects of the origin of life on earth. Amsterdam: Elsevier Publishing, p 106.
12. Kenyon DH, Steinman G. 1969. Biochemical predestination. NY: McGraw-Hill.
13. Miller SL, Urey HC. 1959. Organic compound synthesis on the primitive earth. Science 130:245-251.
14. Urey HC. 1953. Proceedings of the Royal Society of London 219A:281.
15. Ring D, et al. 1972. Prebiotic synthesis of hydrophobic and protein amino acids. Proceedings of the National Academy of Sciences (USA) 69:765-768.
16. Gish DT. 1972. Speculations and experiments related to theories on the origin of life. San Diego, CA: Institute for Creation Research.
17. Bernal JD. 1960. Thermodynamics and kinetics of spontaneous generation. Nature 186:694-695.
18. Hull DE. 1960. Thermodynamics and kinetics of spontaneous generation. Nature 186:693-694.
19. Lawless JG, Boynton CD. 1973. Thermal synthesis of amino acids from a simulated primitive atmosphere. Nature 243:405-407.
20. Fox SW, et al. 1963. Amino acid compositions of proteinoids. Archives of Biochemistry and Biophysics 102:439-445.
21. Krampitz G. 1962. In: Stahmann MA, editor. Polyamino acids, polypeptides and proteins. Madison: University of Wisconsin Press.
22. Fox SW, Harada KW. 1960. The thermal copolymerization of amino acids common to protein. American Chemical Society Journal 82:3745-3751.
23. Fox SW. 1965. A theory of macromolecular and cellular origins. Nature 205:328-340.
24. Fox SW, editor. 1965. The origins of prebiological systems and of their molecular matrices. NY: Academic Press, p 361.
25. Fox SW, Harada K. 1960. Thermal copolymerization of amino acids in the presence of phosphoric acid. Archives of Biochemistry and Biophysics 86:281-285.
26. Vegotsky A, Fox SW. 1959. Pyropolymerization of amino acids to proteinoids with phosphoric acid or polyphosphoric acid. Federation Proceedings 18:343.

27. Steinman G, Lemmon RM, Calvin M. 1964. Cyanamide: a possible key compound in chemical evolution. Proceedings of the National Academy of Sciences (USA) 52:27-30.
28. Steinman G, Kenyon DH, Calvin M. 1965. Dehydration condensation in aqueous solution. Nature 206:707-708.
29. Wald G. 1957. The origin of optical activity. New York Academy of Sciences Annals 69:352-368.
30. (a) Kuhn W, Braun E. 1929. Naturwissenschaften 17:227; (b) Michell S. 1930. Journal Chemical Society 20:1829; (c) Kuhn W, Knopf E. 1930. Naturwissenschaften 18:183.
31. Seifert H. 1956. In: Bechner B, editor. Von Unbelebten zum Lebendigen. Stuttgart: F. E. Verlagslrich Handling, p 68.
32. Blout ER, Doty P, Yang JT. 1957. Peptides. XII. The optical rotation and configurational stability of a-helices. American Chemical Society Journal 79:749-750.
33. (a) Blout ER, Idelson M. 1956. Polypeptides. VI. Poly-a-L-glutamic acid: preparation and helix-coil conversions. American Chemical Society Journal 78:497-498; (b) Blout ER, Idelson M. 1956. Polypeptides. IX. The kinetics of strong-base initiated polymerizations of amino acid-N-carboxyanhydrides. American Chemical Society Journal 78:3857-3858.
34. G. Steinman. 1967. Stereoselectivity in peptide synthesis under simple conditions. Experientia 23:177-178.
35. Kovacs J, Kisfaludy L, Ceprini MW. 1967. On the optical purity of peptide active esters prepared by N,N'-dicyclohexylcarbodiimide and "complexes" of N,N'-dicyclohexylcarbodiimide-pentachlorophenol and N,N'-dicyclohexylcarbodiimide-pentafluorophenol. American Chemical Society Journal 89:183-184.
36. Northrup JH. 1957. Optically active compounds from racemic mixtures by means of random distribution. Proceedings of the National Academy of Sciences (USA) 43:304-305.
37. White A, Handler P, Smith EL. 1968. Principles of biochemistry. NY: McGraw-Hill.
38. Oro J, Kimball AP. 1961. Synthesis of purines under possible primitive earth conditions. I. Adenine from hydrogen cyanide. Archives of Biochemistry and Biophysics 94:217-227.
39. Ferris JP, Sanchez RA, Orgel LE. 1968. Studies in prebiotic synthesis. III. Synthesis of pyrimidines from cyanoacetylene and cyanate. Journal of Molecular Biology 33:693-704.
40. Kemp I, Korhnstorm G. 1956. Journal Chemical Society 46:900.
41. Sanchez RA, Ferris JP, Orgel LE. 1966. Cyanoacetylene in prebiotic synthesis. Science 154:784-785.
42. Beck A, Lohrmann R, Orgel LE. 1967. Phosphorylation with inorganic phosphates at moderate temperatures. Science 157:952.
43. Miller SL. 1957. The formation of organic compounds on the primitive earth. New York Academy of Sciences Annals 69:260-274.
44. Loeb W. 1913. Berichte der Deutsche Bunsengesellschaft für Physikalische Chemie 46:684.

45. Baly E, Heilbron I, Hudson D. 1922. Photocatalyses, the photosynthesis of nitrogen compounds from nitrates and carbon dioxide. Journal Chemical Society 12:1078.
46. Garrison WM, et al. 1951. Reduction of carbon dioxide in aqueous solutions by ionizing radiation. Science 114:416-418.
47. Bahadur K. 1954. Photosynthesis of amino-acids from paraformaldehyde and potassium nitrate. Nature 173:1141.
48. Hough L, Rogers AF. 1956. Synthesis of amino-acids from water, hydrogen, methane and ammonia. Journal of Physiology 132:28P-30P.
49. Paschke R, R. Chang RWH, Young D. 1957. Probable role of gamma irradiation in origin of life. Science 125:881.
50. Abelson PH. 1957. Discussion of S. L. Miller's The formation of organic compounds on the primitive earth. New York Academy of Sciences Annals 69:274-275.
51. Santamaria L, Fleischmann L. 1966. Photochemical synthesis of amino acids from paraformaldehyde catalyzed by inorganic agents. Experientia 22:430-431.
52. Bahadur K, Ranganayaki S, Santamaria L. 1958. Photosynthesis of amino-acids from paraformaldehyde involving the fixation of nitrogen in the presence of colloidal molybdenum oxide as catalyst. Nature 182:1668.
53. Deschreider AR. 1958. Photosynthesis of amino-acids. Nature 182:528.
54. Reid C. 1959. Proceedings of the international symposium on the origin of life on earth. Vol. 1, p 619-625. NY: Pergamon Press.
55. Pavlovskaya TE, Pasynskii AG. 1959. Proceedings of the international symposium of the origin of life on earth. Vol. 1, p 151-157. NY: Pergamon Press.
56. Oro J, et al. 1959. Amino acid synthesis from formaldehyde and hydroxylamine. Archives of Biochemistry and Biophysics 85:115-130.
57. Fox SW. 1960. How did life begin? Science 132:200-208.
58. Lu HK, et al. 1960. Formation of sulfur-containing amino acids by electric discharge in a reductive atmosphere. Chemical Abstracts 54:4209-4210.
59. Oro J, Kamat SS. 1961. Amino-acid synthesis from hydrogen cyanide under possible primitive earth conditions. Nature 190:442-443.
60. Fox SW. 1961. The origins of prebiological systems and of their molecular matrices. NY: Academic Press, p 137-162.
61. Palm C, Calvin M. 1962. Primordial organic chemistry. I. Compounds resulting from electron irradiation of $C^{14}H_4$. American Chemical Society Journal 84:2115-2121.
62. Lowe C, Rees M, Markham R. 1963. Synthesis of complex organic compounds from simple precursors: formation of amino-acids, amino-acid polymers, fatty acids and purines from ammonium cyanide. Nature 190:219.
63. Oro J. 1963. Synthesis of organic compounds by electric discharges. Nature 197:862-867.
64. Steinman GD, Lillevik HA. 1964. Abiotic synthesis of amino groups. Archives of Biochemistry and Biophysics 105:303-307.
65. Harada K, Fox SW. 1964. Thermal synthesis of natural amino-acids from a postulated primitive terrestrial atmosphere. Nature 201:335-336.
66. Kolomiychenko MA. 1965. Photochemical synthesis of amino acids. Federation Proceedings (Translation Supplement) 24:T199-T202.

67. Matthews CN, Moser RE. 1966. Prebiological protein synthesis. Proceedings of the National Academy of Sciences (USA) 56:1087-1094.
68. Choughuley ASU, Lemmon RM. 1966. Production of cysteic acid, taurine and cystamine under primitive earth conditions. Nature 210:628-629.
69. Matthews CN, Moser RE. 1967. Peptide synthesis from hydrogen cyanide and water. Nature 215:1230-1234.
70. Harada K. 1967. Formation of amino-acids by thermal decomposition of formamide — oligomerization of hydrogen cyanide. Nature 214:479-480.
71. Hasselstrom T, Henry MC, Munn B. 1957. Synthesis of amino acids by beta radiation. Science 125:350-351.
72. Dose K, Ponnamperuma C. 1967. The effect of ionizing radiation on N-acetylglycine in the presence of ammonia. Radiation Research 31:650-651.
73. Moser RE, Claggett A, Matthews CN. 1968. Peptide formation from diaminomaleonitrile (HCN tetramer). Tetrahedron Letters 13:1599.
74. Moser RE, Matthews CN. 1968. Hydrolysis of aminoacetonitrile: peptide formation. Experientia 24:658-659.
75. Steinman G, Smith AE, Silver JJ. 1968. Synthesis of a sulfur-containing amino acid under simulated prebiotic conditions. Science 159:1108-1109.
76. Friedmann N, Miller SL. 1969. Phenylalanine and tyrosine synthesis under primitive earth conditions. Science 166:766-767.
77. Friedmann N, Miller SL. 1969. Synthesis of valine and isoleucine in primitive earth conditions. Nature 221:1152-1153.
78. Bar-Nun A, et al. 1970. Shock synthesis of amino acids in simulated primitive environments. Science 168:470-473.
79. Fox SW, et al. 1970. Bio-organic compounds and glassy microparticles in lunar fines and other materials. Science 167:767-770.
80. Nagy B, et al. 1970. Organic compounds in lunar samples: pyrolysis products, hydrocarbons, amino acids. Science 167:770-773.
81. Fox SW, Windsor CR. 1970. Synthesis of amino acids by the heating of formaldehyde and ammonia. Science 170:984-986.
82. Khare BN, Sagen C. 1971. Synthesis of cystine in simulated primitive conditions. Nature 232:577-579.
83. Sagen C, Khare BN. 1971. Long-wavelength ultraviolet photoproduction of amino acids on the primitive earth. Science 173:417-420.
84. Trump JEV, Miller SL. 1972. Prebiotic synthesis of methionine. Science 178:859-860.
85. Ferris JP, Donner DB, Lobo AP. 1973. Possible role of hydrogen cyanide in chemical evolution: investigation of the proposed direct synthesis of peptides from hydrogen cyanide. Journal of Molecular Biology 74:499-510.
86. Ferris JP, Donner DB, Lobo AP. 1973. Possible role of hydrogen cyanide in chemical evolution: the oligomerization and condensation of hydrogen cyanide. Journal of Molecular Biology 74:511-518.
87. Harada K, Iwasaki T. 1974. Syntheses of amino acids from aliphatic carboxylic acid by glow discharge electrolysis. Nature 250:426-428.

88. Ferris JP, et al. 1974. Chemical evolution; the amino acids released on hydrolysis of HCN oligomers. Journal of Molecular Evolution 3:225-231.
89. Garay AS. 1968. Origin and role of optical isomery in life. Nature 219:338-340.
90. G. A. Kerkut. 1960. Implications of evolution. Pergamon Press, New York, p, viii.

# ARTICLES

## SOME PHILOSOPHICAL IMPLICATIONS OF THE THEORY OF EVOLUTION

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*The full import of a particular philosophical view is seldom realized. Some consequences of evolution as it affects man's search for truth are elucidated below.*

Since the close of the last century, the theory of evolution has come to be accepted by the majority of the scientific community and the general public. In fact, to reject evolution is now usually viewed as a sign of ignorance or of a system of religious belief totally at odds with reality and out of place in this modern, "scientific" world.

Unfortunately, few have faced the profound and ominous implications of the evolutionary theory as it affects mankind in every area of his humanity. Those few who have considered evolution's conclusions have sought to side-step them by appealing to a baseless optimism concerning human dignity, freedom, perfectibility and his future on this planet. The first objective of this essay is to suggest that evolution is not primarily a scientific theory, but a comprehensive metaphysical world view that implicitly and explicitly has frightening implications in all of the most important categories of human existence: 1) the possibility of discovering truth, 2) epistemology, the search for an adequate basis for knowing, 3) the existence of human freedom, and 4) the meaning of ethics and human dignity.

The second objective will be to indicate the lack of content within evolutionary humanism. This corollary to the evolutionary theory of the origins of life and man has sought to show that on the basis of evolution, mankind can use his accidentally developed freedom of choice to noble, humanitarian purposes, building a better future for himself and his posterity. However, once the inescapable logical conclusions of the evolutionary theory are squarely faced, it will be evident that hope for a better tomorrow built by man's own efforts is nothing more than a wistful dream.

Within the past few decades, a large segment of Christendom has sought to make peace with evolution by trying to steer a course midway between the prevalent view of mechanistic naturalism and the Biblical account of creation contained in the first chapter of Genesis. While continuing to stress God's initial act in creating the universe and all it contains, they accept evolution as an adequate explanation of His creative activity. Such a view has certain scriptural and scientific difficulties that will not be discussed in this paper. Although such a theistic evolutionary view may be comforting to some, the fact is that the mainstream of evolutionary thinking sees no use for God — not in the origin of the universe, not in the origin and development of life, and not in the origin of man himself. As Sir Julian Huxley has stated, "After Darwin it was no longer necessary to deduce the existence of divine purpose for the facts of biological adaptation."[1]

According to the mechanistic, naturalistic evolutionary theory, the universe, life in general, man himself, are all products of a totally impersonal interaction of matter and energy over vast eons of time. The universe as now known is an accident, life is an accident, and man is an accident. In the words of French molecular biologist and Nobel Prize winner Jacques Monod:

> *Pure chance, absolutely free but blind,* [lies] *at the very root of the stupendous edifice of evolution....The universe was not pregnant with life nor the biosphere with man. Our number came up in the Monte Carlo game.*[2]

To illustrate the pervasiveness of this atheistic, mechanistic view of life, Theodosius Dobzhansky, renowned geneticist at the Davis campus of the University of California, and formerly of Columbia, in a recent review of Monod's best-selling book *Chance and Necessity*, may be quoted:

> *He* [Monod] *has stated with admirable clarity, and eloquence often verging on pathos, the mechanistic materialistic philosophy shared by most of the present 'establishment' in the biological sciences.*[3]

Underlying the evolutionary theory is not just the classic "stuff" of science — conclusions arrived at through prolonged observation and experimentation. Evolution is first an atheistic, materialistic world view. In other words, the primary reason for its acceptance has little to do with the evidence for or against it. Evolution is accepted because men are atheists by *faith* and thus interpret the evidence to correspond to their naturalistic philosophy.

By stressing the accidental nature of origins, evolutionary theory can find no basis for meaning in the cosmos nor in man's very existence, other than what man might, on the basis of chance, be able to find for himself. Charles Darwin in his autobiography understood evolution's serious implications for man. This understanding took the form of the "horrid doubt." He states:

> *But then arises the doubt, can the mind of man, which has, as I fully believe, been developed from a mind as low as that possessed by the lowest animal, be trusted when it draws such grand conclusions?* [The grand conclusion in this context is the evolutionary hypothesis itself].[4]

At the basis of this evolutionary idea was the theory of natural selection, a concept basic to the entire evolutionary edifice. Natural selection, or as Herbert Spencer popularized it — "survival of the fittest" — means simply that certain life forms were able to survive changes in the natural environment because they had evolved through blind chance certain characteristics that enabled them to adapt to those environmental changes.

It is here that Darwin's "horrid doubt" comes into focus. If living organisms survived only on the basis of mindless natural selection, then it inescapably followed that human reason was also the product of natural selection. As such, the conclusions of human reason could never be known to be true, but only valuable in accord with their contribution to the survival of the human species. To use the language of utilitarian philosophy, truth could only be defined as what works, and not necessarily as what is true.

Such an implication for any meaningful human enquiry can cause a "horrid doubt." Man is divorced from being able to discover purpose to existence, for he cannot determine if his conclusions are true. Just as obviously, all scientific enquiry is undermined. As noted biologist and loyal Darwinian David Lack has stated:

> *At this point, therefore, it would seem that the armies of science are in danger of destroying their own base. For the scientist must be able to trust the conclusions of his reasoning. Hence, he cannot accept the theory that man's mind was evolved wholly by natural selection if this means, as it would appear to do, that the conclusions of the mind depend ultimately on their survival value and not their truth, thus making all scientific theories, including that of natural selection, untrustworthy.*[5]

In sum, if natural selection be "true," then man is hopelessly shut off from a true evaluation of the world around him, from any true understanding of the spiritual, and even from a true understanding of himself.

To the Christian mind such a "horrid doubt" could easily be resolved by rejecting a world view inadequate to account for the origin and nature of the universe, of life, and of man in the fullness of his humanity. It would mean abandoning a philosophy that undermines the very existence of reason and destroys any adequate basis for determining truth. The tragedy of modern thought is only recognized when one understands that to abandon an evolutionary, materialistic world view is precisely what man refuses to do.

Calling attention to the consequent deaths of truth, reason and epistemology does not exhaust the significance of Darwin's "horrid doubt." For if man is nothing more than the product of a natural universe consisting only of matter and energy, a universe in which all things are produced by chance, then human dignity, any meaningful concept of ethics, and free will die as well. If man is a biological accident who owes his origin to nothing more than the rolling of some cosmological dice, what is meant by human dignity in the first place? Can human dignity and notions of right and wrong, good and evil, in such a universe be anything more than modes of thought and action that somehow have allowed human societies to function in a reasonably stable fashion? In short, are they no more than "survival value" factors?

Finally, what does one do with the question of free will? Few concepts have been more troublesome to philosophers. Does man possess it? If so, how did he come by it? And if man does have it, how much do such factors as heredity, environment, and the existence or non-existence of the spiritual realm enhance or limit that freedom of choice? As the implications of the evolutionary theory have come to the forefront, a certain attitude toward freedom has become advocated more and more. This is the attitude of behavioral psychology. As B. F. Skinner puts it:

> *The role of natural selection in evolution was formulated only a little more than a hundred years ago, and the selective role of the environment in shaping and maintaining the behavior of the individual is only beginning to be recognized and studied. As the interaction between organism and environment has come to be understood...effects once assigned to states of mind, feelings, and traits are beginning to be traced to accessible conditions, and a technology of behavior may therefore become available.*[6]

In short, man does not independently act upon his environment, but his outward environment, his culture, which was determined by the natural environment, and his own heredity, which was dictated to him by natural selection, program him on how to feel, what to think, and how to react to the world and the people around him. Behavioral psychology, which rests firmly upon an evolutionary, naturalistic world view robs man of his freedom of action and thought just as much as the most vehement Calvinist denies the existence of freedom to the unregenerate sinner. Thus, if mechanistic, atheistic evolution be true, can the seemingly "free" actions of individual human beings be significantly different than mere randomness, as in the random actions of individual atomic particles? To hold to the evolutionary theory and at the same time, in spite of the inescapable conclusions of that theory, hold to a belief in human purpose, dignity, free will, and the meaningfulness of ethics is to involve oneself in an unresolvable dilemma. One could try to escape the dilemma and say that life and man are not solely a product of natural selection. But to do this undermines the central concept and motive force of evolutionary theory. In addition, it allows the entrance of the divine in creation.

At present, modern evolutionary theory is neither prepared to abandon the centrality of natural selection nor to allow any room for God in the creative process. How then does it attempt to reconcile mechanistic, naturalistic evolution with such concepts as the ability of man to comprehend truth? Since most theories are not yet reconciled to the extreme conclusions of behaviorism, the other alternative is to declare that in some mysterious, perhaps forever unknowable way, at some time in the unknowably remote eons past – non-life accidentally produced life, chance produced purpose, matter produced "mind." Though no evidence can ever be mustered to support such gigantic assumptions, this is the way that almost every philosopher of naturalistic evolutionism deals with this critical issue. This explanation brings our discussion of the nature of the evolutionary theory to full circle. Such an explanation illustrates that evolution is fundamentally not a scientific theory, but a true metaphysical and, if you will, religious world view. In no way are its central assumptions open to either empirical verification or falsification.

Though seldom squarely faced, the ominous implications of a mechanistic evolutionary world view for mankind are not being completely lost on modern secular man. As noted psychologist-philosopher Erich Fromm admits:

> *Man is born as a freak of nature, being within nature and yet transcending it. He has to find principles of action and decision making which replace the principles of instinct. He has to have a frame of orientation which permits him to organize a consistent picture of the world as a condition for consistent actions. He has to fight not only against the dangers of dying, starving, and being hurt, but also against another danger which is specifically human: that of becoming insane.*[7]

Thus upon the basis of naturalistic assumptions, man can consider himself to be nothing but an accident, alone in a forever silent universe, without an inherent direction; and if no sense of direction be found, he stands in imminent danger of being plunged into the abyss of insanity.

It is at this very point that we come face to face with the spirit of the age — evolutionary humanism. In spite of the logical and inescapably gloomy conclusions of his naturalistic assumptions, modern secular man mystically holds on to them instead of accepting faith in God. Not only this, he even seeks to find hope in them. Focusing on the concept of progress inherent to evolutionary theory, man hopes somehow, at some time in the not-too-near future, to be able to consciously take control of the evolutionary process, find the proper direction from within himself, and rebuild Eden. In the words of Sir Julian Huxley:

> *The broad outlines of the new evolutionary picture of ultimates are beginning to be clearly visible. Man's destiny is to be the sole agent for the future evolution of this planet. He is the highest dominant type to be produced by over two and a half billion years of the slow biological improvement effected by the blind opportunistic workings of natural selection; if he does not destroy himself, he has at least an equal stretch of evolutionary time before him to exercise his agency.*[8]

What evidence does Huxley then give to support his optimistic pronouncements for mankind's future based on his belief in evolutionary progress? None whatsoever.[9] The very core of evolutionary humanism is hope for the future based upon faith in a theory of man and the universe that is itself based upon faith. This is why Francis Schaeffer refers to modern humanist thought as "upper-storey mysticism."[10] In the realm of the "lower storey" — the logical and empirically verifiable or falsifiable — the basic assumptions of evolution cannot be proven true or false. Furthermore, the logical conclusions to those assumptions lead to the non-existence of human purpose, dignity, free will and the meaninglessness of ethics. Also, the humanistic hope for a better future is likewise without logical or empirical support. The history of the 20th century alone, which has witnessed the slaughter of more men, women and children in its first 75 years than in the previous 5000 years of recorded history combined, does not augur well for a very optimistic future, if man alone must build that future.

Thus, in order to accept evolution in the first place, and then to find hope for the future on the basis of that theory, modern man must make a foundationless leap into an "upper-storey mysticism." It is a mysticism in that the basic assumptions of evolution must be taken wholly by faith. It is a mysticism in that hope for man's future must be based upon a faith that ignores history both past and present, and focuses upon the obviously unverifiable future.

Finally we are forced to ask the question, if an evolutionary, naturalistic world view is so apparently inadequate, then why accept such a belief at all? Is it possibly because the most logical alternative is to embrace the Christian faith? Such an answer is strongly implied by eminent 20th century novelist and philosopher Aldous Huxley, in his book *Ends and Means*:

> *The philosopher who finds no meaning in the world is not concerned exclusively with a problem in pure metaphysics; he is also concerned to*

*prove that there is no valid reason why he personally should not do as he wants to do....*

*For myself, as, no doubt, for most of my contemporaries, the philosophy of meaninglessness was essentially an instrument of liberation. The liberation we desired was simultaneously liberation...from a certain system of morality. We objected to the morality because it interfered with our sexual freedom; we objected to the political and economic system because it was unjust. The supporters of these systems claimed that in some way they embodied the meaning (a Christian meaning, they insisted) of the world. There was one admirably simple method of confuting these people and at the same time justifying ourselves in our political and erotic revolt: we could deny that the world had any meaning whatsoever.*[11]

And what did men like Aldous Huxley use to support such a philosophy of meaninglessness? Evolution through natural selection, which as his brother Julian has stated makes it unnecessary "to deduce the existence of divine purpose for the facts of biological adaptation."

In summary, evolution is not primarily a scientific theory. It is a comprehensive world view that not only seeks to explain the origins of life and man, but also to supply a philosophy of hope built upon an implicit belief that man is answerable to no one but himself. For if evolution be true, then man is the highest being in his universe. And even though he has not yet been able to establish Eden, and in spite of the fact that recorded history gives him little encouragement, the very idea that evolution is inherently progressive fosters hope that he will eventually progress to an even greater state of knowledge, social concern, and control over those aspects of his environment which forestall Eden's construction. That is, provided man doesn't blow himself off the map before evolution can continue.

In *The Gay Science*, Friedrich Nietzsche portrays a madman walking through the marketplace. The madman cries: "I seek God!...Whither is God? I shall tell you....God is dead....And we have killed him. How shall we, the murderers of all murderers, comfort ourselves?"[12] I suggest that modern man has sought his own liberation from God, has sought God's death, through the two-pronged philosophy of evolutionary naturalism and evolutionary humanism. But instead of finding himself in the death of God, man has come face to face with his own death — the death of reason, truth, epistemology, freedom, morality, and his own dignity.

## ENDNOTES


1. Huxley J. 1946. Rationalist annual. London: C. A. Watts & Co., p 87.
2. Monod J. 1971. Chance and necessity. NY: Alfred A. Knopf, p 112, 145-146.

3. Quoted in: Gish DT. 1974. Evolution: the fossils say no. San Diego, CA: Creation-Life Publishers, p 10-11.
4. Frontispiece to: Lack D. 1961. Evolutionary theory and Christian belief: the unresolved conflict. London: Methuen.
5. Ibid., p 104.
6. Skinner BF. 1971. Beyond freedom and dignity. NY: Alfred A. Knopf, p 25.
7. Fromm E. 1963. The revolution of hope: toward a humanized technology. NY: Harper & Row, p 60-61.
8. Huxley J, editor. 1961. The humanist frame. NY: Harper & Brothers, p 17.
9. I believe that a good reading of *The Humanist Frame* will substantiate my assertion.
10. See three excellent works by Dr. Francis Schaeffer for an in-depth examination of the new mysticism: The God who is there (1968. Downers Grove, IL: Inter-Varsity Press); Escape from reason (1968. Downers Grove, IL: Inter-Varsity Press); and Back to freedom and dignity (1972. Downers Grove, IL: Inter-Varsity Press).
11. Huxley A. 1937. Ends and means. London: Chatto & Windus, p 272, 273.
12. Kaufmann W, editor. 1954. The portable Nietzsche. NY: Viking Press, p 95.

# NEWS AND COMMENTS

## AN UPDATE ON THE TEACHING OF CREATION IN CALIFORNIA

In April 1974 the California State Board of Education voted unanimously to include the following statements in the social science framework:

> *Part of humankind's long intellectual history has been the grappling with the question of human origins. In virtually every culture, whether ancient or modern, accounts of human origin have been part of the system of beliefs held by the people of that culture.*
>
> *In the Judeo-Christian tradition, which has been the most influential religious factor in Western civilization, human origin has been explained as an act of divine creation as described in the Book of Genesis. The development of scientific theories of origin in the nineteenth century both added to the variety of explanations of human origin and encouraged a re-evaluation of earlier explanations. For some, the conflict of beliefs caused by the scientific theories has been sharp enough to force them to choose between their system of belief and the evolutionary explanations offered by science. Others have found it possible to accept scientific accounts of human evolutionary development while still holding to a belief in divine creation. Still others believe that the concept of divine creation is scientifically valid.*
>
> *These various views of human origin, together with various approaches to the relationship between religious belief and scientific theory, must be seen as part of the intellectual and cultural diversity of our society. These representative views of origin are studied in the social sciences because they make significant contribution to human systems of belief and values.*

Although this framework was adopted in April 1974, it was not printed until January 1976. Because of a similar issue in Tennessee at that time (see *Origins* 2:96-97), and because of the strong anti-creation sentiment in the scientific community, it was felt the first step should be to place the topics of human origins and the early history of mankind in the social science texts. This was also done to avoid the complication of legal charges from evolutionary scientists.

Significant advances towards including creation in the elementary textbooks of California have been made. A number of books that were eventually adopted for the social sciences in 1975 contained some creation concepts, and a number of evolutionary ideas formerly stated as facts in science texts are now presented only as theories.

Because of the unprecedented two-year delay in the printing of the social science framework, and because of the urgency of including creation theory along with evolution, the State Board of Education adopted the following statement as an addendum to the social science framework.

> *The State Board of Education had determined that the appropriate place for discussing the subject of origins is in the Social Science classroom, K-12. Books on the approved matrix for Social Science do not include an adequate study of the various views of human origin. Notwithstanding, when the matter of origins is studied in Social Science classes, various alternatives should be presented appropriately.*

This directive was distributed throughout all the school districts of the State of California to be added to the social science framework, thus informing the school districts that the Board does expect creation to be included in the teaching of the history of early man.

A definite victory has been won by the creationists in having materials on creation printed in the textbooks, and in notifying all school districts in the State of California that they are expected to teach alternate views when dealing with the subject of origins.

John R. Ford, M.D.
California State Board
of Education

# NEWS AND COMMENTS

## STUDY IN THE JOHN DAY COUNTRY

When information from science and sacred history are studied together, one's conclusions differ from those deduced when each is studied alone. The purpose of the Bible-Science Subcommittee is to explore the relationship of these two avenues of information. Previous reports of this group's activities are given in *Origins* 1:37-39; 2:44-45. The May 1975 meeting was held in Prineville, Oregon, near the John Day Country, famous for its fossil mammals and plants (Figure 1).

Three participants at the conference had made extensive studies of the John Day Country. Stuart Nevins (a guest from the Institute for Creation Research) who had already published on the geology of the area provided particularly valuable assistance throughout the conference. Harold Coffin, from the Geoscience Research Institute, described the geology of the Pacific Northwest as an orientation for a field trip. Ervil Clark of the Biology department at Pacific Union College exhibited a number of specimens which he had collected in the area and discussed the significance of their depositional environments. During a full-day field trip through the John Day Country, problems were faced with candor, and evidence was cited which supports transport of many fossil remains rather than growth at the site of deposition.

A number of papers at the conference were based on material reported in past meetings of the committee. Eleven of the studies were presented by individuals who received their advanced education in the area of the empirical sciences. Leonard Brand of the Biology department at Loma Linda University with pictures and other evidence showed that fossil vertebrate footprints in the Coconino Sandstone of the Grand Canyon are similar to those made in very wet sand or under water. This evidence is more consistent with a flood model than with the commonly accepted wind-blown sand model. Dwain L. Ford, Dean of the College of Arts and Sciences, Andrews University, reviewed various theories regarding the origin of evaporites (minerals formed by evaporation) and suggested a model which could account for the formation of major salt beds within the context of a flood model. Harold Coffin reported on accumulating evidence from directional orientation which suggests that many fossil remains were transported rather than growing in the location where they are now found. Three computer studies were presented by Ray Hefferlin of the Physics department at Southern Missionary College. By using a computer terminal at the meeting in Prineville, participants were able to

**FIGURE 1. Dr. Dwain L. Ford examining a petrified upright tree trunk in the Triassic Clarno Formation near Hancock Park in central Oregon. His right hand rests in the cast of a horizontal tree trunk.**

determine the quantitative distribution of water on the earth under postulated conditions. His other reports dealt with variations in C-14 production with different creation and flood models.

Ariel A. Roth, chairman of the Bible-Science Subcommittee, surveyed seven lines of evidence which support a flood model: reduced provinciality in the fossil record, spores of land plants in the lowest Paleozoic sediments, prevalence of turbidites, extent of sedimentary deposit, paucity of erosional features at unconformities, paucity of local depositional features, and inconsistencies of various time clocks. Harold James of the Geoscience Research Institute reported on sedimentary characteristics of some Miocene deposits in Colombia, South America, and the importance of these characteristics in interpreting the past. Ivan Holmes, Associate Dean of Arts and Sciences at Loma Linda University, and Richard Martin, a student, described X-ray diffraction analysis of alternating mineral layers from the Petrified Forests north of Specimen Creek in Yellowstone National Park. Arthur Chadwick of the Biology department at Loma Linda University suggested a test to determine if trees of the Yellowstone Petrified Forests grew in place or were transported. He proposed that if large roots often end abruptly, this would constitute critical evidence against growth at the site of deposition. He also described logistic problems encountered in searching for such evidence. James Riggs of the Physics department at Loma Linda University discussed the difficulties of developing a model which can account for the cooling of batholiths with an approximately 6000-year chronology for life on the earth.

Three of the papers were written by those who approached the theme of the committee from a theological viewpoint. Dalton Baldwin of the Division of Religion at Loma Linda University suggested that ideas rejecting a scientific approach to religion may be seen as harmonious with those advocating a scientific approach to religion, if the rejected science is found to be science “falsely so-called” and the recommended science is true science. Raymond F. Cottrell, secretary of the Bible-Science Subcommittee, surveyed recent developments in astrophysics and cosmology and discussed their relationship to origins. Gerhard Hasel, Assistant Dean of the Theological Seminary at Andrews University, presented a paper on Genesis cosmology which showed the striking differences from other cosmologies of the Near East. He placed emphasis on creation as the absolute point of origin, God Himself as creator, creation by divine fiat, and the limitation of the creation account to this earth.

Considerable time was devoted to the development of a statement of belief with respect to creation. The chairman of the committee had prepared a questionnaire designed to pool the judgment of the participants regarding various factors which might be included in the statement. The Geoscience staff was requested to draw up a statement reflecting the oral and written responses to the questionnaire for presentation at the next meeting.

The stimulation of the carefully prepared papers and the subsequent active discussions challenged the participants to further study in preparation for the forthcoming meeting to be held at Price, Utah, where extensive coal deposits are found.

Dalton D. Baldwin

# 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.*

## ANCESTRAL DISSONANCE

UNIQUENESS AND DIVERSITY IN HUMAN EVOLUTION. Charles Oxnard. 1975. Chciago: The University of Chicago Press. 128 p.

*Reviewed by Edward N. Lugenbeal, GeoscienceResearch Institute*

Since the publication in the late 19th century of Huxley's *Man's Place in Nature* and Darwin's *The Descent of Man*, both of which took a determined naturalistic and evolutionary view of human origins, the search for man's direct ancestors has been intense. The fruits of this search have been relatively modest. Of great interest, however, to the question of the biological origins of man was the discovery by Raymond Dart in 1924 of a fossil he classified into a new genus, *Australopithecus* ("southern ape"). Dart was impressed by the transitional nature of *Australopithecus* and interpreted the genus as an ancestor of modern man.

Just what *Australopithecus* was saying (if anything) about human origins was debated with enormous animation and some animus right from the start. In fact, few anthropologists believed Dart at first. But by the late 1940s, Dart's "heresy" had become "orthodoxy." Nearly everyone agreed that some, at least, of the *Australopithecus* fossils were man's direct ancestors. Between 1950 and 1970, the interpretation of *Australopithecus* as ancestral to man became so strongly entrenched in anthropology that it was hard for many to take seriously those who "refused" to see the light. But recently almost invisible strains, then distinct fissures have begun to accumulate in the ruling model until suddenly it is neither difficult nor professionally hazardous to find full-fledged faults in it.

The book by Charles Oxnard, *Uniqueness and Diversity in Human Evolution*, will contribute to the slowly gathering momentum of the attack on standard views. In view of the new fossil finds by Leakey (1973) and others, its publication comes at an opportune time. Yet there is nothing opportunistic about its appearance. Charles Oxnard is one of a small group of scholars that never wavered in its rejection of the prevailing view of *Australopithecus*. The center of this resistance was the anatomy department of the University of Birmingham in England, and its vociferous leader Solly Zuckerman (1966). Oxnard, it should be noted, came to the University of Chicago via the anatomy department of the University of Birmingham.

As McHenry (1975) notes, Oxnard's book can be seen as a sort of scholarly tit-for-tat in the long controversy surrounding the Birmingham school's refusal to accept *Australopithecus* as ancestral to man. Early in the controversy Zuckerman and Ashton challenged the prevailing view of *Australopithecus* by publishing a study of *Australopithecus* teeth that contradicted the general assumption that these teeth were basically human in shape. (The man-like teeth and presumed upright bipedal gait of *Australopithecus* have long been cited as clear evidence of human ancestry.) In response, Lang and the late Bronowski, now well known for his "Ascent of Man" television series, claimed that Zuckerman's and Ashton's results were misleading because of the univariate methodology employed. Instead of making a series of measurements and comparing each measurement, Bronowski and Lang proposed the use of multivariate statistical techniques. Multivariate statistical analysis is very complex, necessitating the use of a computer, but the net result is that all the measurements made on a given specimen contribute simultaneously to the comparison, giving an over-all estimate of affinity. Bronowski and Lang analyzed the deciduous canine of an *Australopithecus* and, not too surprisingly, concluded it was basically human.

Oxnard and his colleagues have responded to the challenge by using multivariate techniques to study the *Australopithecus* shoulder, pelvis, talus, toe, metacarpal, and humerus. The results, it is claimed, do not support the idea that *Australopithecus* was ancestral to man. So now Oxnard could say (if he were less polite), "univariate or multivariate, take your pick, all analytic roads lead back to Birmingham and to the conclusion that *Australopithecus* is not ancestral to man." What Oxnard does say is this:

> *...The various Australopithecines, viewed as a single group at the higher taxonomic level, are generally more similar to one another than any individual specimen is to any living primate. They are uniquely different from any living form to a degree comparable at least to the differences among living genera. The manner in which they are similar to living apes and man is either such as is applicable to all living apes and man, or such that displays special morphological resemblances to a particular ape, the orangutan...* (p 119).
>
> *...We may well have to accept that it is rather unlikely that any of the Australopithecines...can have any direct phylogenetic link with the genus Homo* (p 122).

If Oxnard is correct, the Australopithecines do not have as much to tell us about human *origins* as has been assumed. However, these fossil bones can still be instructive about human *nature*. In reviewing the history of their interpretation, one is impressed with the inconsistency with which the critical powers of man (scientist and layman) are applied. The validity of evidence or interpretations that support one's viewpoints is accepted with astonishing ease. Critical analysis is perfunctory at best. Arguments submitted under the banner of opposing viewpoints are dissected with incredible energy and thoroughness!

This aspect of human nature makes openness to diverse viewpoints imperative in any scientific or scholarly community. Proponents of a particular viewpoint will not, indeed, usually *cannot*, probe the seamier sides of their theories. Normally, models are only really put to the test by advocates of opposing models — such are the psychological limitations of human nature. Therefore, dissidents must be cherished in science. Far from threatening the community, they are its irreplaceable creative catalysts. Any scientific community that does not cherish its dissidents, no matter how exasperating, blind, misguided or downright stubborn they may appear, has already taken the first step away from science. The Birmingham school, including Charles Oxnard, has obviously done anthropology a great service over the years in stoutly resisting the conventional wisdom concerning *Australopithecus*. We can be grateful that the scientific establishment, if it did not always really listen to them, did at least cherish these dissidents to the extent that it gave them a forum to be heard and financial and institutional support.

Most "creation scientists" will not find it difficult to cherish Oxnard and colleagues. In removing the Australopithecines from the ancestry of modern man, the result has been, as Duane Gish (1975) puts it, "to practically clear the field of supposed transitional forms between man and apes." On the other hand, creationists committed (on religious grounds) to the discontinuity between man and ape may find it difficult to keep their critical powers functioning relative to the work of Oxnard. This would be a mistake, for there are serious criticisms that can be raised.

For all its sophistication and complexity, multivariate analysis of morphology is still relatively untested. There are numerous mathematical and procedural difficulties, not all of which have been satisfactorily resolved. It is not all that certain that results achieved are really better than the "intuitive" comparisons of form by the human eye and brain, which can automatically assimilate and integrate far more information than can be incorporated in even "multivariate" studies. In any event, any qualified analysis of form is only as good as the measurements that provide the raw data. The myth of objectivity is stripped from these methods when it is realized that the analyst must decide what to measure and how to measure it. Interpretation is already active as decisions are made to measure certain dimensions because these are the "critical" ones that reveal functional differences. For example, McHenry (1975) notes that "the unusual way Oxnard and his colleagues measure the pelvic bone...appears to bias the results so that one unique feature of the Australopithecine pelvis (wide flaring of the iliac blades) greatly affects a large proportion of the measurements."

Creation scientists have repeatedly appealed to sample bias in rejecting anthropological interpretations of fossil man. The complaint that whole genera and species of early man have been raised from a few isolated bones has been expressed often and eloquently. But this complaint is equally justified in evaluating Oxnard's work. Oxnard's conclusions concerning *Australopithecus* are based on the analysis of less than a dozen bones, some of which are considered apart from their larger skeletal context. The talus analyzed by Oxnard comes from a complete foot found at Olduvai that appears to my eye amazingly similar to the human foot. Likewise, the *Australopithecus* pelvic bone used in the analysis comes from a complete, although reconstructed, pelvic girdle which also looks strikingly similar to the pelvic girdle in man (see also McHenry 1975).

Because multivariate analysis of form is still in its infancy and isn't as objective as some of its practitioners would like to think, we shouldn't be too surprised if other scholars take up the multivariate challenge once more and using different measurements conclude that *Australopithecus* is ancestral to man. We probably have not seen the end of multivariate "one-upmanship" in the interpretation of *Australopithecus*.

I do not wish to disparage multivariate analysis of morphology. It is clearly a field of great promise and interest. Yet at this stage of its development, one is reminded of the tongue-in-cheek rejoinder of the geologist F. J. Vine. When asked if he had tested his material statistically, Vine retorted, "I never touch statistics. I just deal with the facts" (Vine 1968). Fortunately, an increasing store of facts is becoming available as new fossil finds are made, especially in East Africa (Leakey 1973). These finds suggest that Oxnard is correct in denying that *Australopithecus* was ancestral to modern man. It is these fossils, more than Oxnard's multivariate statistics, that will complete or abort the revolution in the interpretation of the Australopithecines that is aborning.

## LITERATURE CITED

Gish D. 1975. Multivariate analysis: man...apes...Australopithecines...each uniquely different. ICR Impact Series No. 29. Institute for Creation Research Acts and Facts 4(9):ii.

Leakey REF. 1973. Evidence for an advanced Plio-Pleistocene hominid from East Rudolf, Kenya. Nature 242:477-480.

McHenry HM. 1975. A view of the hominid lineage. Science 189:988.

Vine FJ. 1968. Magnetic anomalies associated with mid-ocean ridges. In: Phinney RA, editor. The History of the Earth's Crust, p 87. NJ: Princeton University Press.

Zuckerman S. 1966. Myths and methods in anatomy. Journal of the Royal College of Surgeons of Edinburgh 11(2):87-113.

# GENERAL SCIENCE NOTES

## *NEOPILINA*: A LIVING FOSSIL

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On May 6, 1952, ten living specimens of an extraordinary mollusc were discovered. While trawling off the Pacific coast of Costa Rica, the Danish deep-sea "Galathea" expedition hauled these specimens to the ocean surface from a depth of 3590 meters. They were given the name *Neopolina galathea* and their discovery has been described as "the most dramatic one in the history of malacology." It was an unusual discovery in more than one way.

*Neopilina* has a single dome-shaped shell reminiscent of limpet shells. Before *Neopilina* was discovered, similar fossil shells were known. Originally these fossil shells were classified either as chitons (class Polyplacophora) or limpets (class Gastropoda, which includes snails, slugs, etc.). Eventually, however, a new molluscan class was established for these fossils based on a unique characteristic of the shell. On the inner surface of the shell, several pairs of serially arranged muscle scars occur. This new class was called Monoplacophora. (literally, single-plate-bearer).

When *Neopilina* was discovered it became the only living representative of Monoplacophora. For this reason it is often referred to as a "living fossil." Living fossils are unique extant organisms that are representative of much larger fossil groups. They are remnants of an otherwise extinct type of organism. Living fossils occur among both plants and animals. Other than *Neopilina*, plants and animals commonly referred to as living fossils are the horsetails or scouring rushes, the gingko or maidenhair tree, the coelacanth fish, the horseshoe or king crab, the chambered nautilus and the brachiopod *Lingula*.

*Neopolina* is a particularly interesting example of a living fossil. Although the genus *Neopilina* does not occur in the fossil record, it closely resembles the genus *Pilina* that does. *Pilina* occurs in Silurian (Paleozoic) deposits low in the geologic column. Neither *Pilina* nor *Neopilina* occur elsewhere in the fossil record. *Neopilina* is said to so closely resemble *Pilina* that "the differences may prove to be of only subgeneric value."

The significance of a Recent organism closely resembling Silurian fossils is best appreciated when it is realized that according to the commonly accepted geologic time scale, 400 million years stretch between the Silurian and Recent. In the context of the evolution paradigm (model), this means that *Neopilina* underwent only insignificant changes in 400 million years. Is it any wonder that the discovery of *Neopilina* was met with surprise? In the case of *Neopilina,* such a slow rate of change has been explained as the result of the supposedly stable deep-sea environment in which it lives.

Since the initial discovery of *Neopilina* in 1952, several other similar specimens have been collected. At least five species have been described. All specimens have been collected in deep water ranging from about 2000 to more than 6000 meters deep. Collections have been made in the eastern and central Pacific, the south Atlantic, and the western Indian Oceans. Although reasonably widespread, they have gone undetected until relatively recently — presumably because of their restriction to deep water.

The discovery and occurrence of *Neopilina* at great depths served to strengthen a theory held by some scientists that the deep-sea contains a high percentage of "ancient life." ("Ancient life" need not imply a long chronology. It could, for example, include living fossils and other organisms that occurred in the deep-sea and were buried during the Genesis flood.) These scientists supposed that the constancy of the deep-sea environment provided a place of refuge for the survival of ancient life. It was expected that in further sampling of the deep-sea fauna, much ancient life would be discovered. In general, this expectation has not been fulfilled. *Neopilina* is an apparently anomalous group in this respect. Other than possibly some Foraminifera (protozoans), it is apparently the only Paleozoic living fossil that is known to occur in the very deep oceans.

Evidence is now accumulating that the deep-sea is not the unchanging environment it was once considered to be. Thus, it could not have served as a refuge for ancient life. Changes in the bottom sediments and deep-sea temperatures have occurred. Present deep-sea temperatures are apparently much lower (at least 15ºC) than in the past. A significant temperature decrease would have eliminated any ancient life that may have previously existed in the deep-sea. It is possible that a deep-sea, as it is now known, did not even exist when sediments low in the geologic column (Paleozoic) were deposited, since Paleozoic deposits do not occur in the deep ocean basins.

What this means in the context of a creation/flood paradigm is not certain. There may not have been any deep-sea or deep-sea fauna in the antediluvial world. Alternately, an antediluvial deep-sea fauna may have existed but was destroyed by catastrophic sediment and temperature changes during the Genesis flood. Colonization or repopulation of the deep-sea would be a post-flood event and the "ancient" antediluvial organisms would not generally occur there today.

The discovery of living fossils permits the study of the biology of an almost extinct group of organisms in ways that would be impossible from the preserved hard parts of the fossils alone. They provide living links to now generally extinct groups. As previously mentioned, in the fossil Monoplacophora, a unique serial repetition of paired muscle scars occurred on the inner surface of the shell. Interestingly, although originally a main characteristic of the group, these muscle scars do not occur in the single living representative of the group. *Neopilina* does, however, have 8 pairs of serially arranged pedal (foot) retractor muscles. Not only are the muscles serially arranged, but there is a serial repetition of paired nerve connectives, nephridia (kidneys), gills, and to a lesser extent, perhaps gonads and auricles.

Molluscs are not ordinarily considered to be a segmented group; yet this serial succession of structures suggested to scientists describing *Neopilina* that it might be a segmented group of molluscs. This had considerable significance in the evolution paradigm because it made *Neopilina* a potential "missing link" between the unsegmented molluscs and the segmented annelids (earthworms, etc.) and arthropods (insects, spiders and crabs). It seemed to provide a pathway between segmented and nonsegmented organisms.

The discovery of a "missing link" is an important event for the evolutionary invertebrate zoologist because the gaps between the major invertebrate groups are so strikingly difficult to bridge. The difficulty of doing so is emphasized by the numerous contradictory theories that have been proposed to bridge the gaps. Some of these are outlined by G. A. Kerkut in his book *Implications of Evolution*. Although writing within the evolution paradigm, he forcefully demonstrates the great difficulty in establishing phylogenetic (evolutionary) relationships between the invertebrate groups.

With further study of *Neopilina* many scientists now feel that its segmentation is fundamentally different than that found in either the annelids or arthropods. It is doubted that it has a truly segmented type structure. In either case, a common designer (creator) of the annelids, arthropods and molluscs may well have incorporated common features in all three groups. Similarities between groups do not prove phylogenetic relations between groups.

*Neopilina* was thought to support the ancient-life hypothesis for the deep-sea. It was also designated a missing link. Now many scientists consider *Neopilina* anomalous rather than supportive in the first instance and an unlikely candidate in the second. The story of *Neopilina* emphasizes a phenomenon inherent in the scientific method. New data and changing interpretations can quickly make previously held positions untenable. This is both the strength and weakness of the scientific method — strength coming from openness to new ideas, weakness from the fact that present ideas may be incorrect.

## BIBLIOGRAPHY


Hyman LH. 1967. The invertebrates: Mollusca I. NY: McGraw-Hill Book Co.

Kerkut GA. 1960. Implications of evolution. NY: Pergamon Press.

Lemche H. 1957. A new living deep-sea mollusc of the Cambro-Devonian class Monoplacophora. Nature 179:413-416.

Marshall AJ, Williams WD, editor. 1972. Textbook of zoology: invertebrates. NY: American Elsevier Publishing Co., Inc.

Meglitsch PA. 1972. Invertebrate zoology. 2nd ed. NY: Oxford University Press.

Menzies RJ, George RY, Rowe GT. 1973. Abyssal environment and ecology of the world oceans. NY: John Wiley and Sons.

# EDITORIAL

## ZEAL AND HOAXES

Several years ago a story about a missing day was publicized by a number of newspapers and other public media. This story purported that a group of scientists at the Goddard Space Flight Center, Greenbelt, Maryland, were studying the varying positions of the planets of our solar system as they relate to time. They were unable to find exact agreement between ancient historical data and expected dates. As a result of this, the computer that was processing the data quit. When corrections were made for Joshua's long day as described in the Bible (Joshua 10:13), near-perfect agreement was obtained. When a second correction was made for the moving back of the sun for King Hezekiah (2 Kings 20:9-11), perfect agreement was the result. Confidence in the accuracy of the Bible was thus enhanced.

Investigation of this account by several individuals has proved disappointing. The individual reporting the incident could not remember where the data were obtained from originally, and no one at the Goddard Space Flight Center seems to have been involved in this somewhat dramatic computational incident. It does not appear that this event ever took place. Some have tried to exonerate the incident by emphasizing the good purposes and intentions involved. Others have pointed out that the event should not be taken so seriously, since a number of individuals who believed in the accuracy of the Bible never did accept the story, but the incident still remains as an embarrassment to defenders of the Bible.

During the second decade of this century Charles Dawson and Sir Arthur Smith Woodward announced the discovery of the now-famous Piltdown human remains in Sussex county in southern England. The Piltdown skull remained in more or less good standing for decades as one of the evolutionary intermediates between man and lower forms. The brain case was remarkably human while the jaw was more ape-like, corresponding to the then-prevailing idea that the brain led the way in human evolutionary development. Some researchers also reported finding primitive features related to the more modern human cranium. About 30 years later three renowned anthropologists announced that the Piltdown skull was a hoax. The jaw had been stained and the teeth had been filed to make them match the more modern cranium. Relative dating by the fluorine technique showed the jaw to be younger than the cranium.

Some have tried to exonerate this incident by pointing out that there always were some who questioned the validity of the Piltdown findings. However, at least for a while, the skull won a respected position on man's proposed evolutionary tree, and the incident remains as an embarrassment to the defenders of evolution.

One is loath to implicate specific motives in both of the episodes reported above, but that they occurred and that for a time each argument was promoted as valid by supporters of creation or evolution should have an important lesson for us. Both incidents are embarrassing. They suggest that unreasonable zeal for what one believes to be true may destroy confidence in the very truth being promoted. This should be avoided. Truth does not need the support of error.

When something is perceived to be true, it should be communicated, but one should not resort to supporting that conclusion with false or carelessly gleaned information. Such a procedure is crippling to the truth-gathering process. To those who do not recognize the erroneous information, error becomes a part of their creed; to those who do recognize it, "truth" becomes tainted. or rejected along with falsehood. In either case pollution is encountered, and such should be studiously avoided.

The two incidents reported above are rather clear cases of corruption of the truth-gathering process. Of greater concern are those situations where the cases are not so clear and more careful scrutiny is necessary to detect error. Well-meaning individuals may betray a lack of thoroughness. Implications and conclusions gleaned from carelessly obtained data may be no better or may be even worse than the poor data themselves. The inferential perspectives colored by these partially erroneous conclusions can have very broad effects. Of similar importance is the problem of selection of data where accurate data on only one side of a question are presented while opposing data are ignored. This also gives a false view and stifles truth. The significance of this issue is seldom appreciated as it should be.

Let us have more zeal for accuracy.

Ariel A. Roth

# 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: ORIGINS**

I want to express my sincere appreciation for the contributions your fine journal has made to me personally. Those articles of a theological nature have proved to be of special value. I would cite three articles as outstanding:

"*The Fountains of the Great Deep*," by Hasel

"*The Biblical View of the Extent of the Flood*," by Hasel

"*Some Philosophical Implications of the Theory of Evolution*," by Clark

I certainly hope that this high quality of scholarship will continue to express itself in *Origins*.

Stan Udd
Acting Chairman
for the Graduate Division
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# ARTICLES

## THE CHEMICAL COMPOSITION OF THE EARTH'S ORIGINAL ATMOSPHERE

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*It has often been postulated that the original atmosphere of the earth was a reducing one. Such an atmosphere, unlike the present oxidizing kind, would facilitate the formation and survival of those molecules believed to be associated with the spontaneous origin of life. The author discusses some of the cosmological, geological, and biological evidence related to this important issue.*

According to a popular theory of the origin of life, which has attained almost the status of orthodoxy in the world of science, a variety of physico-chemical processes led to the formation and accumulation of biologically important, simple organic compounds early in the earth's history. These molecules combined together to give more and more complex products until one was formed that could be called living.[1] Oxygen rapidly degrades the majority of organic compounds and inhibits many of the metabolic reactions in living systems, and therefore the original proponents of this theory postulated that the primitive earth must have had a reducing atmosphere devoid of oxygen.[2,3]

In 1953 Miller carried out his famous experiments in which reducing atmospheres of methane, ammonia, water and hydrogen were subjected to electric discharges and a wide variety of organic compounds, including amino acids, were formed.[4] Numerous experiments purporting to simulate primitive earth conditions with a variety of gas mixtures and energy sources have subsequently confirmed that amino acids and other bio-organic molecules are synthesized under reducing conditions,[5,6] but not in the presence of oxygen.[6-9] Bio-organic compounds are not forming in significant quantities in the earth's present atmosphere or hydrosphere (except in living organisms) and therefore the initial steps in this mechanism for the origin of life depend crucially on the nature and composition of the earth's original atmosphere. In this article the cosmological, thermodynamic, and geological evidence bearing on this question is reviewed. It is found that the facts are in better agreement with an early oxidising atmosphere similar to the present one.

### A. FEASIBILITY AND STABILITY OF A REDUCING ATMOSPHERE

#### 1. Cosmological Evidence

In the most generally held theory of the origin of the solar system, the sun and planets are supposed to have condensed from a dust cloud having the same average composition as the universe. The cosmic abundances of a selection of elements are given in Table 1, which shows that hydrogen and helium are by far the most abundant.

**TABLE 1**

**Terrestrial and cosmic abundances of selected elements.[10]**

| Element | Atomic Weight | Cosmic Abundance ($Si=10^6$) | Terrestrial Abundance (ppm) | Terrestrial Abundance / Cosmic Abundance |
|---|---|---|---|---|
| Oxygen | 16 | $2.9\times10^7$ | 456,000 | |
| Silicon | 28 | $1\times10^6$ | 273,000 | |
| Aluminium | 27 | $9\times10^4$ | 83,600 | |
| Iron | 56 | $8.5\times10^4$ | 62,200 | |
| Calcium | 40 | $7.3\times10^4$ | 44,600 | |
| Magnesium | 24 | $1\times10^6$ | 27,640 | |
| Sodium | 23 | $4.2\times10^4$ | 22,700 | |
| Hydrogen | 1 | $3.2\times10^{10}$ | 1,500 | |
| Carbon | 12 | $1.7\times10^7$ | 180 | |
| Nitrogen | 14 | $3\times10^6$ | 19 | |
| Helium | 4 | $2.6\times10^9$ | | — |
| Neon | 20 | | | $10^{-10}$ |
| Argon | 36 | | | $10^{-9}$ |
| Krypton | 84 | | | $10^{-7}$ |
| Xenon | 131 | | | $10^{-7}$ |

Early workers in this field therefore concluded that the earth must originally have had an atmosphere rich in hydrogen and the reduced compounds of other elements such as ammonia, methane and water, somewhat similar to the atmosphere known to exist on the heavy planets such as Jupiter and Saturn, but containing less helium and hydrogen as these light elements would escape from the earth's gravitational field. A major difficulty with this view is the relatively low amount of the rare gases on the earth compared to their cosmic abundances. The ratios of the cosmic abundances of the rare gases to their terrestrial abundances are given in Table 1, and it is apparent that the earth contains many orders of magnitude less neon, argon 36, krypton and xenon than it should if it were condensed from average cosmic matter.

This view has now largely been abandoned in favour of the idea that volatile elements such as hydrogen were lost from the earth during the condensation stage while the gravitational field was weak. The earth's reducing atmosphere is then supposed to have accumulated by outgassing of the interior by volcanic and allied activity. It is difficult to accept that xenon and krypton with atomic weights of 131 and 84 respectively could be so thoroughly lost from this early gravitational field, and yet methane, ammonia and water, and a host of lighter compounds be retained. Even if the additional hypothesis that these molecules were retained in chemically combined form, such as carbonates and ammonium salts, is advanced, it would still be expected that much of the rare gases should be retained by occlusion within dust particles and larger fragments composing the cloud. Argon, for example, is trapped with fair efficiency in rocks, and this is an important factor in the potassium-argon dating technique. The extremely low terrestrial abundances of the rare gases are still, to say the least, surprising. The chemically combined forms of carbon and nitrogen so far detected in cosmic dust clouds are volatile, low molecular weight compounds such as formaldehyde, hydrogen cyanide, methanol and acetaldehyde.[11] The most natural conclusion from this is that the earth's composition has always been unlike the average of the universe.

Gases evolving from present-day volcanoes vary in composition with locality and time. Typical compositions of the emanations from some volcanoes and fumaroles are shown in Table 2. Steam and carbon dioxide are usually the main constituents, but occasionally hydrogen, carbon monoxide, sulphur dioxide or hydrogen chloride may be important. Methane and ammonia are rarely found, and then usually in trace quantities only. The hypothesis that the earth acquired a reducing atmosphere by volcanic outgassing finds little support in the evidence from present-day volcanoes. The hypothesis can be bolstered by making the additional assumption that volcanic gases were much more reducing in the past.[13] This sheds no further light on the problem since it is merely the complement of the original reducing atmosphere hypothesis. It is interesting to note that Precambrian igneous rocks closely resemble their modern counterparts in chemical composition (see below).

## 2. Kinetic and Thermodynamic Considerations

Can molecules such as methane, ammonia, or carbon monoxide in contact with the ocean, the earth's crust, and in the presence of sunlight persist for geologically significant periods of time? Methane is the thermodynamically stable carbon compound in the presence of excess hydrogen:

$$CO_2 + 4H_2 \longrightarrow CH_4 + 2H_2O\ (liq) \qquad K = 8\times10^{22}$$
$$CO + 3H_2 \longrightarrow CH_4 + H_2O\ (liq) \qquad K = 2.5\times10^{26}$$
$$C + 2H_2 \longrightarrow CH_4 \qquad K = 8\times10^{8}$$

In the absence of hydrogen, however, ultraviolet light and electric discharges readily decompose methane, which also reacts with water to give carbon dioxide and carbon monoxide. Carbon monoxide reacts quite rapidly with ocean water (pH 8.1) to give formate:

$$CO + OH^- \longrightarrow HCO_2^-$$

and it is unlikely that carbon monoxide could persist even in a reducing atmosphere.

Ammonia is formed from nitrogen and hydrogen in a fairly favourable process:

$$^1/_2N_2 + {^3/_2}H_2 \longrightarrow NH_3 \qquad K = 8\times10^{2}$$

## TABLE 2

**Composition of volcanic and fumarolic gases.[12]**

| VOLCANO OR FUMAROLE | $CO_2$ | CO | $CH_4$ | $NH_3$ | $H_2$ | HCl | HF | $H_2S$ | $SO_2$ | %$H_2O$ |
|---|---|---|---|---|---|---|---|---|---|---|
| Showa-shinzan A1 Japan | 65 | — | 0.1 | 0.1 | 25 | 5 | 3 | 0.1 | 1.7 | 99.2 |
| Showa-shinzan B4b Japan | 92 | — | 0.2 | — | 4 | 2 | 0.5 | 1.0 | 0.4 | 90.1 |
| Sheveluch Kamchatka | 60 | 3 | — | — | 5 | 1 | — | — | 32 | — |
| Biliuka Kamchatka | — | 28 | — | — | 26 | 46 | — | — | — | — |
| Valley of 10,000 Smokes, Alaska | 60 | — | 0.2 | — | — | — | — | 40 | — | 99.9 |
| Mount Hood Oregon | 96 | — | 0.1 | — | 0.3 | — | — | 3 | — | 98.7 |
| White Island New Zealand | 73 | — | — | — | — | 25 | — | — | 2 | 95 |
| Kilauea Hawaii | 96 | 1.7 | 0.4 | — | — | — | — | — | 1.6 | — |
| Novarupta Alaska | 79 | 0.2 | 12.5 | — | — | — | — | 7.9 | — | 98.8 |
| Mont Pelée Martinique | 100 | — | — | — | — | — | — | — | — | — |
| Ambrym New Hebrides | 88 | 1.2 | — | — | — | — | — | — | 9.8 | 22.7 |
| Nyiragongo Zaire | 84 | 5.6 | — | — | 1.6 | — | — | — | 9.1 | 43.2 |
| Vesuvius Italy | 84 | — | — | — | 9.5 | 6.0 | — | — | — | 67.7 |
| Soufrière de la Guadeloupe | 69 | — | 1.3 | — | — | — | — | 6.1 | 24 | 91 |

Composition given as volume percent for each gas excluding water.
Water is given as percentage of total gases.

but it is also rapidly destroyed by ultraviolet radiation; so that a quantity of ammonia equivalent to the present atmospheric nitrogen would be degraded in this way in 30,000 years.[14] Ammonia is also highly soluble in water and would dissolve in the ocean to form ammonium ions thus effectively being removed from the atmosphere.[15]

The indications are that carbon monoxide and ammonia could not persist in the atmosphere in contact with the ocean, and the availability of methane depends on a constantly supplied reservoir of hydrogen in the atmosphere. At present there is relatively little hydrogen available in the earth's crust (see Table 1). According to the dust cloud model for the formation of the earth, the majority of the hydrogen and other volatiles would have been lost before consolidation of the earth.[16] Any hydrogen surviving this process, or being produced by photodissociation of water vapour or by volcanic emanation, is also rapidly lost from the earth's gravitational field because of its low molecular weight.

The exact rate of loss of hydrogen is difficult to assess, since it depends on the rate of diffusion of hydrogen to the escape layer, and the temperature and diameter of the exosphere, none of which can be known for the primitive earth. At present the temperature of the escape layer is extremely high (~1500°K) so that almost all hydrogen getting there escapes. It seems doubtful that hydrogen (and hence methane, ammonia or other reduced gases) could ever have reached substantial concentrations in the atmosphere, and in view of this the formation and persistence of a reducing atmosphere must be considered unlikely under any geologically plausible conditions.

One of the most significant facts in this area, which is often overlooked, is the great abundance of oxygen available on the earth. It is by far the most abundant element in the earth's crust (see Table 1) which is largely composed of oxides of silicon, calcium, aluminium and other metals.[17] Since oxygen is also very abundant in the universe, being third in magnitude after hydrogen and helium, it is probable that very great amounts must have been present from the beginning, regardless of the mechanism for the formation of the earth. Furthermore, oxygen is also overwhelmingly abundant combined with hydrogen in the hydrosphere.

If we assume for the moment that oxygen had been absent from the atmosphere at some time, then several mechanisms exist which would rapidly build up its concentration. Water vapour is dissociated by ultraviolet radiation in the upper atmosphere to give hydrogen, most of which escapes into space, and oxygen which is retained by the earth's gravitational field:

$$2H_2O \longrightarrow 2H_2 + O_2$$

Urey[18] has suggested that production of oxygen in this way would be limited because the oxygen formed would absorb the ultraviolet light needed to photodissociate the water. This self-regulating mechanism depends on the difference in vertical distribution of oxygen and water in the atmosphere. Oxygen is distributed exponentially, but water is arrested in a cold trap in the troposphere. Oxygen would rise much higher in the atmosphere, and since oxygen and water absorb radiation substantially in the same region of the spectrum, the water would be screened from further dissociation as soon as sufficient oxygen built up.[19] Berkner & Marshall[20] presented detailed calculations which showed that this mechanism would limit oxygen in the atmosphere to about one thousandth of its present atmospheric level. Brinkmann, however, reconsidered this problem and showed that Berkner & Marshall's calculations were invalid because they ignored the pathlength dependence of the oxygen absorption and the dissociation of water when it was a minor absorber.[21] Brinkmann showed that the Urey self-regulation mechanism is much less effective than was formerly supposed, and that oxygen could have reached an appreciable fraction of the present atmospheric level from water dissociation alone. He concludes that the atmosphere could have been oxidising over a large fraction of geologic time. Direct observations from the moon during the Apollo 16 mission revealed that substantial amounts of hydrogen are leaving the earth's atmosphere, due to photochemical water dissociation in the upper atmosphere.[73]

A second important mechanism for the production of oxygen is photosynthesis by living organisms. The rate of oxygen production is extremely high, and it is estimated, for example,[22] that at the present time all the oxygen in the atmosphere passes through the photosynthetic cycle in 2000 years, and all the carbon dioxide in 300 years. The oldest known rocks contain evidence of photosynthetic organisms, although this is by no means conclusive (see below). Van Valen has pointed out that when oxygen is produced in photosynthesis, a stoichiometrically equivalent quantity of reduced carbon is also formed.[22] If oxygen had built up from a very low concentration to the present atmospheric level, there should be an accumulation of reduced carbon in the earth equivalent to far more than the reserves of coal and oil now known. Van Valen considers that there is no satisfactory mechanism for regulating oxygen concentrations at very low levels.

When sedimentary rocks are subjected to high pressures and temperatures in metamorphic processes in the earth's crust, the dominant chemical process occurring is progressive loss of water:

$$\underset{\text{kaolinite}}{Al_4Si_4O_{10}(OH)_8} + \underset{\text{quartz}}{SiO_2} \rightarrow \underset{\text{pyrophylite}}{2Al_2Si_4O_{10}(OH)_2} + 2H_2O$$

$$\underset{\text{analcime}}{NaAlSi_2O_6 \bullet H_2O} + SiO_2 \rightarrow \underset{\text{albite}}{NaAlSi_3O_8} + H_2O$$

$$\underset{\text{muscovite}}{KAl_2(AlSi_3O_{10})(OH)_2} \rightarrow \underset{\text{orthoclase}}{KAlSi_3O_8} + \underset{\text{corundum}}{Al_2O_3 + H_2O}$$

With carbonate minerals carbon dioxide can be formed, and oxygen can also be produced in gas-solid reactions involving abundant minerals:

$$\underset{\text{calcite}}{CaCO_3} + SiO_2 \rightarrow \underset{\text{wollastonite}}{CaSiO_3} + CO$$

$$\underset{\text{hematite}}{Fe_2O_3} + SiO_2 \rightarrow \underset{\text{fayalite}}{Fe_2SiO_4} + \tfrac{1}{2}O$$

This process is probably not important as a direct contributor to atmospheric oxygen, since volcanic gases rarely contain oxygen, but the dominant position of water and carbon dioxide in volcanic emanations is readily explained. A facile route is seen to exist for the transfer of oxygen from the vast reservoirs in the rocks to the ocean where it can be used in photolysis or photosynthesis and thence to the atmosphere.

## B. GEOLOGICAL EVIDENCE

It might be expected that conclusive evidence regarding the earth's original atmosphere could be obtained from a study of the oldest known rocks in the Precambrian formations. Unfortunately, Precambrian rocks have suffered extensively from metamorphic and diagenetic processes which have altered their original form and content chemically and physically. Most of the exposed rocks have suffered so much that most of the evidence of their early history has been destroyed. An additional problem is the contamination of the ancient rocks with material of recent origin carried in by circulating ground water or processes of diffusion. Interpretation of the evidence is a highly subjective process and, not surprisingly, geologists are divided amongst several schools of thought. Rutten has presented the position favouring an early reducing atmosphere very persuasively in his book *The Origin of Life by Natural Causes.*[23] Another school of thought favours the view that the atmosphere has been oxidising since the formation of the earliest crustal rocks.[24]

### 1. Oxidation State of Iron in Precambrian Rocks

Evidence commonly cited as favouring an early reducing atmosphere is the preponderance of the reduced form of iron in Precambrian formations. Rankama, for example, reported that ferrous oxide predominated over ferric oxide in Precambrian conglomerates from Suodenniemi, Finland.[25] Nanz also found a preponderance of ferrous iron in Precambrian slates from Michigan and Wisconsin.[26] The fact that oxidised forms of iron occur at all in the Precambrian might be taken to indicate an oxidising atmosphere. Even the oldest known sedimentary rocks from the Isua iron formation in Greenland contain bands of magnetite ($Fe_3O_4$) of intermediate oxidation state.[27] Vast quantities of magnetite and hematite are present in Precambrian iron formations, which would require an immense amount of oxygen for their formation from reduced iron compounds. Where could all this oxygen come from if not directly or indirectly from the atmosphere?[28]

The preponderance of ferrous iron might seem significant until it is recognised that metamorphic processes often lead to partial reduction of iron[26] and that many reducing environments are known on the earth at the present day. Reducing conditions prevail deep in the earth's crust, and materials brought to the surface by volcanic activity or rising hydrothermal waters are commonly in reduced form. Fyfe suggested that the ferrous oxide in Precambrian rocks is simply a reflection of the enhanced volcanism prevailing in earlier times.[24] Reducing conditions also hold sway in deep waters such as the Norwegian fjords and the Black Sea[29] and in the northern

Indian Ocean.[30] Throughout geologic time and even today, ferrous iron is effectively transported and deposited by subsurface waters.[31] The fact that all oxidation states of iron, from hematite to magnetite to siderite ($FeCO_3$) to pyrite ($FeS_2$), have been found in sediments of all ages merely indicates that the oxidation state of sediments depends primarily on local conditions that do not reflect the average atmospheric composition at the time of deposition.

## 2. Uraninite and Pyrite in Precambrian Gold-Uranium Reefs

Precambrian deposits in the Dominion and Witwatersrand Reefs, South Africa; Serra de Jacobina, Brasil; and Blind River, Ontario, districts contain ancient conglomerates and sands cemented to a very hard rock carrying grains of uraninite ($UO_2$), pyrite and ilmenite ($FeTiO_3$). The origin of these gold-uranium blanket ores has been controversial for more than half a century. In 1958 Ramdohr suggested they could be considered as sediments laid down under an anoxygenic atmosphere and presented evidence for repeated cycles of weathering-erosion-transportation-sedimentation, indicating that these beds must have been in repeated contact with the contemporaneous atmosphere. The reduced state of the pyrite and uraninite (the stable form of uranium under present-day atmospheric conditions is $UO_3$) was taken as an indication of an anoxygenic atmosphere at the time of deposition.[32,23] Davidson, on the other hand, maintains that the uranium and pyrite ore bodies have been formed within the earth's crust long after the mother rock sediments were laid down, by infiltration of hydrothermal metal-bearing solutions, and that they cannot be explained in terms of abnormal atmospheric conditions.[24,28] Even Rutten, an enthusiastic supporter of the reducing atmosphere hypothesis, admits that the deposits show extensive effects of hydrothermal processes.[33]

If, however, it could finally be proved that the uraninite and pyrite deposits are sedimentary in origin, there is no need to invoke an anoxygenic atmosphere to explain their formation. The thermodynamically stable uranium oxide under an atmosphere of oxygen is $UO_3$, and consequently $UO_2$ converts to this, but the rate of conversion depends strongly on the physical form of the uraninite. Conversion is rapid for finely divided or powdered $UO_2$, but granular or compacted material is stable indefinitely[34] and it is even used, fabricated into rods, as fuel elements for nuclear reactors. Grains of uraninite would be expected to remain unchanged during erosion, transportation and deposition even under the present oxygenic atmosphere. Zeschke has shown that uraninite is transported as minute grains by the Indus River in Pakistan at the present day.[35] Furthermore, in the Mozaan rocks of Swaziland, deposited concurrently with the Witwatersrand strata, and in the Lorrain sandstones of Ontario, almost contemporary with the Blind River conglomerates, heavy mineral assemblages, completely of modern aspect, are widely developed.[24] This indicates that the uranium-pyrite ores, which are themselves strikingly similar to recent deposits except for the presence of uraninite and pyrite grains,[36] cannot be explained in terms of abnormal atmospheric conditions.

Many of the Precambrian mineral deposits are associated with carbonaceous matter. Uraninite and pyrite are frequently found in association with thucolite, a carbonaceous mineral, and kerogen, which is graphitized organic matter resembling medium- to high-grade coal.[37, 38] Pyrite is deposited in present-day environments, such as the Black Sea, by the action of bacterial sulphate-reducers.[39] Micro-organisms are known to play an important role in the deposition and concentration of many minerals. The presence of carbonaceous matter in Precambrian ore deposits has generated interest in the possibility that they owe their formation to oxygen-producing or oxygen-utilising micro-organisms.[40] According to Koen the uranium was fixed and concentrated by biological action,[41] and it has been observed that the gold-uranium reefs of the carbon seam type of the Kaapvall Craton are confined to environments expected to favour algal growth.[42] Schidlowski, on the other hand, has advocated an origin for the thucolite involving migration of biogenic compounds into the conglomerates where they are exposed to radiation from the uranium and undergo condensation and polymerization reactions, finally solidifying as carbonaceous material around individual uraninite grains.[37] Doubt has been cast on this hypothesis by observations on Precambrian thucolite occurrences in Australia which showed that the substance does not have the properties expected of a radiolytic polymer.[43]

Obviously no final conclusions can be drawn at present, but there must be a strong presumption that photosynthetic organisms are involved, particularly for pyrite. Further support for this view comes from the isolation of chemical fossils including porphyrins from the carbonaceous material (see below).

### 3. Precambrian Banded Iron Formations

Another type of rock which is supposed to provide evidence of an anoxygenic atmosphere is the banded iron formation; composed of thin laminae of finely crystalline silica alternating with thin laminae of iron ore, the iron being mainly in the ferrous state. Cloud has repeatedly championed the view that the banded iron formations, which are most common in the middle Precambrian, represent unoxidised sediments laid down under a reducing atmosphere and that as the atmosphere became more oxidising towards the end of the middle Precambrian, the banded iron formations cease and are replaced by oxidised sediments known as red beds.[44,23]

There are many difficulties associated with this view. Even the most ancient banded iron formations contain hematite and magnetite,[27] which were at least partly laid down in the primary deposition of the formations.[45] Fully oxidised minerals also occur in formations contemporary with the banded iron formations. Bedded iron ores in the Pretoria series of the Transvaal system (middle Precambrian) are mainly hematite-chamosite or magnetite-chamosite oölites akin to the Wabana ores of Newfoundland and other Phanerozoic formations,[28] which clearly contradicts the hypothesis of an anoxygenic atmosphere. There is no clear distinction in time between the cessation of banded iron formations and the onset of red bed formation. Banded iron formations of late Precambrian and even younger age are known, although they are not common.[45,31] A minority of geologists also consider that the banded iron formations are of volcanic origin,[46] their reduced state having no direct connection with atmospheric conditions.

The majority view is that the deposits are sedimentary in origin, but the orthodox explanation of the thin laminations of iron ore does not require the presence of an anoxygenic atmosphere. It is proposed that weathering processes bring the more soluble ferrous iron down to deep lakes where it is trapped in solution in the deeper oxygen-free waters. Ferrous iron is then precipitated as soon as mixing of the waters brings oxygen to the lower water body.[47,48] Environments such as this are common in present-day lakes.

Red beds are sandstone, siltstone or mudstone made of detrital grains set in a reddish-brown matrix or cemented by precipitated ferric oxide. They occur in great variety and complexity, and their origin and mode of formation have been something of an enigma for years.[49] Red beds are in fact known from the middle and early Precambrian, contemporary with the banded iron formations, although they are not common. Red beds are found in the Uyansk and Uchursk series of the Siberian platform, in the Roraima formation, South America, in the Lorrain formation of the Huronian in Ontario and possibly also in the much older Muruwa formation of Guiana.[28]

Most of the oxidised iron in red beds is not considered to be an original constituent of the rock but to have been produced *in situ* by post-positional chemical changes.[47,48] There is some evidence that the relative lack of red beds in the early Precambrian is because corresponding deposits are in the process of metamorphism whereby the red pigment is dissolved out by ground waters containing magnesium, and the mineral chlorite is then precipitated.[28]

## 4. Geological Evidence of an Early Oxygenic Atmosphere

The proponents of an early reducing atmosphere have focused attention on certain special features of Precambrian strata considered above, but this evidence needs to be evaluated in the light of the overall situation in the Precambrian. The oldest rocks on earth are rather similar to modern ones, the sedimentary rocks being “rather normal,” indicating that the oceans at the time were rather similar to modern ones.[50] Much the same kinds of sedimentary rocks are found in Precambrian as in Paleozoic and younger rocks:[51,52] they are water laid and imply the existence of a substantial hydrosphere and atmosphere for weathering processes.[53] Sedimentary rocks found in the Precambrian are lithologically comparable with those of younger age,[54,55] and igneous rocks of early Precambrian age closely resemble modern rocks in chemical composition.[46] Although the size of the ocean in earlier times remains a matter of debate, there is no evidence that sea water chemistry has ever changed substantially, and it is commonly assumed that its pH and composition have been constant from the earliest times.[50,56] The atmosphere-hydrosphere-lithosphere interaction is an extremely complex one, and the similarities in ancient and modern rocks and sediments clearly imply an atmosphere little different from the present.

All minerals except oxides are unstable in chemical weathering under an oxygenic atmosphere. The ions derived from weathering when transported into areas of sedimentation recombine, mostly forming clay minerals. Clays are as abundant in the early Precambrian as at present.[57] In a reducing atmosphere, weathering is expected to be much slower and quite different in character, since feldspars, dark minerals, sulphides etc., would be chemically unaffected, and weathering would take place by minor physical processes such as frost splitting and sun blasting.[58] The maturity of many Precambrian sediments, the roundness of sand grains, and the well-worn pebbles and cobbles found in early Precambrian conglomerates demonstrate that weathering, erosion and sedimentation went on then as now. Pettijohn considers that such mature weathering could not have been accomplished in the absence of some kind of plant cover.[72] Modern lateritic soils require humic acid derived from vegetation, living in an oxygenic environment, for their development. Precambrian banded iron formations, which resemble lateritic soils, are thought by some to have been formed in a similar way. This view is supported by the finding of frequent intercalations of graphite, possibly of biological origin in the iron formations.[46]

Limestone is produced at present by the growth of green algae in calcium-bicarbonate-rich ground waters in an oxygenic environment. Inorganic deposition of limestone in stalactite caves is also known, but this is normally almost negligible in sunlit areas. Limestone deposits, although not abundant, are found in early, middle and late Precambrian times. Some of these deposits may be biogenic; for example, those described from the Bulawayan system, of early Precambrian age, by MacGregor[59,60] and the prolific development of similar structures in the middle Precambrian of Finland[61] which are entirely comparable with recent algal reefs.

Since limestone is known to be deposited by green algae living in an aerobic environment, one may propose that the Precambrian atmosphere, at the time of deposition of the limestone reefs, was also oxidising. Of course it is always possible to postulate that the metabolism of lime-depositing algae in the past must have been quite different.[57] The soundest procedure, however, is to utilise the modern analogy and work from the known present to the unknown past. Limestone deposition by anaerobic fermenting organisms, though possible, would be expected to produce material of quite different chemical and physical composition, whereas the Precambrian deposits are notably similar to modern equivalents.

Chert or flint is an extremely fine-grained silica which forms, at the present day, by the chemical action of sea water on the siliceous skeletons of plankton such as Diatoms and Radiolaria. It also forms by concretionary action in rocks after their emergence from the sea, and in lacustrine limestones. Enormous amounts of cherts occur in Precambrian strata such as the banded iron formations, where indirect evidence for a biological origin is provided by its association with organic matter, including in some cases actual microfossils.[38]

Phosphorites are deposits which in modern examples of formation develop from phosphatic phytoplankton living by photosynthesis in the uppermost 50 m of the ocean. Many occurrences of Precambrian phosphorites are known, such as those from the Upper Krivoi Rog series of middle Precambrian age, or the deposits of Slyudganka in eastern Sayan and the even older phosphorites in the Baikal region, all from the U.S.S.R.[28] The present-day mode of formation of cherts and phosphorites strongly suggests the Precambrian equivalents developed in an oxygenic atmosphere.

### 5. Macrofossils, Microfossils and Chemical Fossils

Considerable evidence has accumulated in recent years indicating that the carbonaceous matter found in the Precambrian strata is of biosynthetic origin. The nature of this material also suggests that some of it was derived from oxygen-utilising and oxygen-producing organisms. Great caution needs to be exercised in the evaluation of this data because of the problem of contamination. Recent studies with the finest grained cherts and shales from the Precambrian have shown that they are significantly permeable to the flow of fluids and that organic material of modern derivation can be carried into the rock matrix by circulating ground waters.[62,63] At present there are no wholly sound criteria for distinguishing between organic material laid down with the host rock and contamination of recent origin.

A second problem concerns the genuineness of the microfossils, many of which have very simple forms such as spheres or rods. Inorganic artifacts such as colloidal salts after drying can give rise to similar structures, and artifacts composed of iron, silica and other materials could certainly occur in sediments. The microfossils are generally accepted as genuine, but the possibility of “pseudofossils” cannot be ruled out.

**TABLE 3**
**Fossil evidence of Precambrian life.**

| ROCK UNIT | AGES × $10^{-9}$ YEARS* | Stromato-lites | Micro-fossils | $\delta$ $^{13}C^{\#}$ | n - Alkanes | Isoprenoids | Steranes | Fatty Acids | Porphyrins | Amino Acids | Carbo-hydrates |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Brioverian Chert | 0.6 | × | × | × | × | × | ? | | | | |
| Bitter Springs Form. | 0.8 | × | × | × | × | × | | ? | | ? | |
| Skillogalle Dolomite | 1.0 | × | × | × | × | × | | | | | |
| Nonesuch shale | 1.0 | | × | × | × | × | × | | × | | |
| Belt supergp. | 1.1 | × | × | × | | | | | | | ? |
| Muhos shale | 1.3 | | × | × | × | × | | | | | |
| Beck Spring Dolomite | 1.3 | × | × | × | | | | | | | |
| McMinn Form. | 1.5 | | × | × | × | × | | | | | |
| Paradise Creek Form. | 1.5 | × | × | × | ? | ? | | ? | | | |
| Urquhart shale | 1.5 | | × | × | × | × | | | | | |
| McArthur gp. | 1.6 | × | × | × | × | × | | | | | |
| Vallen gp. | 1.8 | × | × | × | × | × | | ? | | ? | |
| Koolpin Form. | 1.9 | × | | × | | | | | | | |
| Gunflint Iron Form. | 2.0 | × | × | × | × | × | | ? | | ? | |
| Brockman Iron Form. | 2.0 | | ? | × | | | | | | | |
| Transvaal supergp. | 2.1 | × | × | × | ? | | | | × | ? | |
| Witwatersrand supergp. | 2.3 | × | × | × | × | | | | × | ? | ? |
| Pokegama quartzite | 2.3 | | × | | | | | | | | |
| Coutchiching gp. | 2.6 | | | | | | | | | | × |
| Soudan Iron Form. | 2.7 | | × | × | ? | ? | ? | ? | | | ? |
| Bulawayan gp. | 2.9 | × | × | × | × | | | | | ? | |
| Fig Tree gp. | 3.2 | | × | × | × | × | | | × | ? | |
| Swartkoppie Form.‡ | 3.4 | | × | × | × | × | | | × | ? | |
| Kromberg Form.‡ | 3.4 | | × | × | × | × | | ? | × | ? | |
| Theespruit Form.‡ | 3.4 | | | × | | | | | × | ? | |

* Approximate ages according to standard geological texts: not endorsed by author.
\# × indicates a $\delta^{13}C$ value characteristic of biogenic material.
‡ Formations of the Onverwacht group.
? Suspected modern contamination or dubious identification.

The only macrofossils that are of widespread occurrence in the Precambrian are stromatolites: metric-sized mounds with a characteristic laminated structure. These are reef-like remnants usually presumed to have been formed from precipitated mineral matter on the enlarging surfaces of microbial communities (usually dominated by blue-green algae) growing by photosynthesis.[64] Stromatolites are known from the Bulawayan group of early Precambrian age, and are widespread in the middle and late Precambrian. The fossil stromatolites bear a marked resemblance to modern ones forming at Hamelin Pool near Shark Bay, Australia.[64,65]

The Onverwacht and Fig Tree groups of the Swaziland system, South Africa, are considered to be the oldest relatively unmetamorphosed rocks known. Numerous globular, filamentous and rod-like microfossils have been found in cherts and shales from both these rock groups. Analysis of these structures has shown that the outer walls definitely contained carbon compounds and many authorities accept that they are of biological origin; but because of their very simple structure some doubts remain.[38,64,67] Undoubted microfossils of diverse and structurally complex micro-organisms are relatively abundant in rocks of middle Precambrian age. For example a great wealth of forms is encountered in the Gunflint formation,[66] with variations between filamental and spheroidal, between septate and non-septate, all pointing to a varied and intricate morphology, such as is only exhibited by living matter. Other middle and late Precambrian localities where microfossils have been discovered are indicated in Table 3.[38,67]

Part of the carbonaceous matter in ancient sediments is extractable by solvents, but most of it is graphitized material (kerogen). A variety of chemical fossils, or "biological markers," have been identified in the extractable fractions from Precambrian cherts and shales. The occurrence of *n*-alkanes, isoprenoids such as pristane and phytane, steranes, fatty acids, metal chelated porphyrins, amino acids and carbohydrates from the early, middle and late Precambrian formations is indicative of a biological origin for much of the material.[68] The porphyrins, and pristane and phytane, which are possibly degradation products of the side-chains of chlorophylls, are particularly suggestive of photosynthetic organisms. They have been identified in the most ancient sediments from the Onverwacht and Fig Tree series.[38] Amino acids have also been found in rocks throughout the Precambrian;[69] however, serine and threonine, which are known to degrade rapidly on the geological time scale, were also discovered. The amino acids in the Fig Tree and Gunflint formations were also shown to comprise the L-isomers only,[70] whereas racemisation is known to be rapid.[68] Contamination from modern sources seems the probable explanation, and the significance of all the chemical fossils is called into question.

The non-extractable kerogen was almost certainly laid down at the time of formation of the host rock. Fractionation of the stable carbon isotopes mass 12 and 13 occurs in living systems and is measured in terms of $\delta^{13}C$, negative values indicating material of biological origin and near zero or positive values characterising inorganic carbon-containing remains.[71] In Table 3 are shown the Precambrian formations having negative $\delta^{13}C$ values characteristic of biogenic material.

Taken together this comprises an impressive array of evidence that life has been present on the earth since the formation of early Precambrian sediments.

## C. CONCLUSIONS

The occurrence of a reducing atmosphere on the earth depends on the availability of hydrogen, but hydrogen is known to escape rapidly from the earth's gravitational field because of its low molecular weight. Hydrogen is not a major constituent of the crust at present, and according to the dust cloud theory of the earth's formation, no large reservoir of hydrogen survived consolidation of the earth. Furthermore, there do not appear to be efficient processes for maintaining a flow of hydrogen to the atmosphere, volcanic evolution of hydrogen being minor. The origin and persistence of a reducing atmosphere is therefore difficult to envisage, particularly when the reactivities of reduced gases such as carbon monoxide and ammonia with the ocean are considered.

Oxygen must always have been of major importance in the earth's crust; the composition of the earliest igneous and sedimentary rocks and of the Precambrian ocean, as well as its cosmic and terrestrial abundance, all attest this. Efficient gas-solid reactions are known which transfer oxygen in the form of water, from the vast reservoirs in rocks to the ocean, and two major processes, photolysis of water vapour and photosynthesis, transfer oxygen to the atmosphere. In the light of this evidence, no other conclusion than that oxygen has always been an important constituent of the atmosphere seems possible.

Geological evidence indicates that rocks from the earliest Precambrian are lithologically quite normal and have similar modern counterparts. Weathering, transportation and sedimentation appear to have taken place essentially as at present. Certain sediments containing minerals in reduced form can readily be accounted for in terms of local reducing conditions, such as are found in many areas today, or they are found to be stable in their lower oxidation state sufficiently long enough for erosion, transportation and deposition. There appears to be no persuasive evidence that the atmosphere has ever differed substantially from its present composition. The presence of oxygen in the earth's original atmosphere would, of course, have a dramatic inhibitory effect on the synthesis and accumulation of organic molecules and would virtually rule out the possibility that life arose in this way.

The presence of limestone, and other probably biogenic sediments, of stromatolites, microfossils, chemical fossils and biogenic kerogen in early Precambrian rocks suggests that life originated virtually simultaneously with the formation of the crust of the earth.

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## ENDNOTES

1. Miller SL, Orgel LE. 1974. The origins of life on the earth. Englewood Cliffs, NJ: Prentice-Hall, p 1.
2. (a) Oparin AI. 1924. Proischogdenie Zhizni. Moscow: Moscovsky Rabotchii; (b) 1953. The origin of life. 2nd English edition. NY: Dover Publications.
3. Haldane JBS. 1929. Science and human life. Rationalist Annual 148:3.
4. Miller SL. 1953. A production of amino acids under possible primitive earth conditions. Science 117:528.
5. Lemmon RM. 1970. Chemical evolution. Chemical Reviews 70:95.
6. Fox SW, Dose K. 1972. Molecular evolution and the origin of life. San Francisco: W.H. Freeman, chapter 4.
7. (a) Abelson PH. 1956. Amino acids formed in “primitive atmospheres.” Science 124:935; (b) Abelson PH. 1957. Discussion of S.L. Miller’s The formation of organic compounds on the primitive earth. New York Academy of Sciences Annals 69:274; (c) Abelson PH. 1966. Chemical events on the primitive earth. Proceedings of the National Academy of Sciences (USA) 55:1365.
8. Miller SL, Urey HC. 1959. Organic compound synthesis on the primitive earth. Science 130:245.
9. Heyns K, Pavel K. 1957. Zeitschrift fur Naturforschung 12b:97.
10. Fairbridge RW. 1972. Encyclopedia of geochemistry and environmental sciences. NY: Van Nostrand Reinhold.
11. (a) Snyder LE, Buhl D. 1973. Sky and Telescope 45:156; (b) 1971. Chemical constituents of interstellar clouds. Nature 234:332; (c) Rank DM, Townes CH, Welch WJ. 1971. Interstellar molecules and dense clouds. Science 174:1083.
12. (a) MacDonald GA . 1972. Volcanoes. Englewood Cliffs, NJ: Prentice-Hall, p 324; (b) Whyte DE, Waring GA. 1963. Volcanic emanations. Washington.
13. Miller & Orgel (Endnote 1), p 13-15.
14. Abelson (Endnote 7c).
15. Miller & Orgel (Endnote 1), p 47.
16. Fowler WA, Greenstein JL, Hoyle F. 1961. Synthesis of deuterons and the light nuclei during the early history of the solar system. American Journal of Physics 29:393.
17. Poldervaart A. 1955. Chemistry of the earth’s crust. Geological Society of America Special Paper 62:119.
18. Urey HC. 1959. In: Oparin AI, et al., editors. The Origin of Life on the Earth, p 16. London: Pergamon Press.
19. It should be recognised that if this mechanism is efficient, ultraviolet light would also not be available for the synthesis of amino acids etc., except in the upper atmosphere above the oxygen and ozone screen, where they would be particularly vulnerable to decomposition.

20. (a) Berkner LV, Marshall LC. 1965. Journal of Atmospheric Science 22:225; (b) Berkner LV, Marshall LC. 1966. Limitation on oxygen concentration in a primitive planetary atmosphere. Journal of Atmospheric Science 23:133.
21. Brinkmann RT. 1969. Dissociation of water vapour and evolution of oxygen in the terrestrial atmosphere. Journal of Geophysical Research 74:5355.
22. Van Valen L. 1971. The history and stability of atmospheric oxygen. Science 171:439.
23. Rutten MG. 1971. The origin of life by natural causes. Amsterdam: Elsevier Publishing.
24. (a) Davidson CF. 1963. The Precambrian atmosphere. Nature 197:893; (b) Fyfe WS. 1974. Geochemistry. Oxford: Clarendon Press, p 87-94.
25. Rankama K. 1955. Geologic evidence of chemical composition of the Precambrian atmosphere. Geological Society of America Special Paper 62:651.
26. Nanz RH. 1953. Chemical composition of pre-Cambrian slates with notes on the geochemical evolution of lutites. Journal of Geology 61:51.
27. Moorbath S, O'Nions RK, Pankhurst RJ. 1973. Early Archean age for the Isua iron formation, West Greenland. Nature 245:138.
28. (a) Davidson CF. 1965. Uranium in ancient conglomerates. Proceedings of the National Academy of Sciences (USA) 53:1194; (b) Davidson CF. 1964. Geochemical aspects of atmospheric evolution. Economic Geology 59:168.
29. Bluck BJ. 1969. Introduction to sedimentology. In: Eglinton & Murphy (Endnote 68), p 248.
30. See: Fox & Dose (Endnote 6), p 44.
31. Golditch SS. 1973. Ages of Precambrian banded iron-formations. Economic Geology 68:1126.
32. Ramdohr P. 1958. Unweathered pyrite and pitchblende in early Precambrian conglomerates. Abhandlungen der Deutschen Akademie Wissenschaft Berlin, Klasse Chemie, Geologie und Biologie, No. 3.
33. Rutten MG. 1963. The Precambrian atmosphere. Nature 197:893; see also Endnote 23.
34. Cordfunke EHP. 1969. The chemistry of uranium. Amsterdam: Elsevier Publishing.
35. Zeschke G. 1960. Transportation of uraninite in the Indus River Pakistan. Transactions of the Geological Society of South Africa 63:87.
36. See: Rutten (Endnote 23), p 260-272.
37. Schidlowski M. 1968. Advances in organic geochemistry. London: Pergamon Press, p 579.
38. McKirdy DM. 1974. Organic geochemistry in Precambrian research. Precambrian Research 1:75.
39. Berner RA. 1970. Sedimentary pyrite formation. American Journal of Science 268:1.
40. Taylor GH. 1971. Society of Mineralogy and Geology of Japan. Special Issue No. 3, p 283.
41. Koen GM. 1961. The genetic significance of the size distribution of uraninite in Witwatersrand blankets. Transactions of the Geological Society of South Africa 64:23.

42. Viljoen RP, Saager R, Viljoen MJ. 1970. Mineralium Deposits 5:164.
43. Taylor GH. See Endnote 38, p 119.
44. Cloud P. 1974. Evolution of ecosystems. American Scientist 62:54.
45. Rutten (Endnote 23), p 276.
46. See: Lepp H, Golditch SS. 1964. The origin of Precambrian iron formations. Economic Geology 59:1025.
47. Hough JL. 1958. Fresh-water environment of deposition of Precambrian banded iron formations. Journal of Sedimentary Petrology 28:414.
48. Govett GJS. 1966. Origin of banded iron formations. Geological Society of America Bulletin 77:1191.
49. Van Houten FB. 1964. Origin of red beds — some unsolved problems. In: Nairn AEM, editor. Problems in Palaeoclimatology, p 647. NY: John Wiley.
50. Fyfe (Endnote 24), p 99.
51. Cloud PE. 1969. Pre-Paleozoic sediments and their significance for organic geochemistry. In: Eglinton & Murphy (Endnote 68), p 727.
52. Pettijohn FJ. 1943. Archean sedimentation. Geological Society of America Bulletin 54:925.
53. Cloud PE. 1968. Atmospheric and hydrospheric evolution on the primitive earth. Science 160:729.
54. (a) Murray GE. 1965. American Association of Petroleum Geologists Bulletin 49:3; (b) Wildman TR, Haskin LA. 1973. Rare earths in Precambrian sediments. Geochimica et Cosmochimica Acta 37:419, 439.
55. Sidorenko AV. 1969. Doklady Akademiya Nauk SSSR 186:36.
56. Sillen LG. 1967. How have sea water and air got their present compositions? Chemistry in Britain 3:291.
57. Rutten (Endnote 23), p 311, 319.
58. Ibid., p 254.
59. MacGregor AM. 1940. Transactions of the Geological Society of South Africa 43:9.
60. Young RB. 1940. Transactions of the Geological Society of South Africa 43:17.
61. Härme M, Perttunen V. 1963. Comptes Rendus des Sèances de la Société Geologique de Finlande 35:79.
62. Nagy B. 1970. Porosity and permeability of early Precambrian Onverwacht chert: origin of the hydrocarbon content. Geochimica et Cosmochimica Acta 34:525.
63. Sanyal S, Marsden SS, Kvenvolden KA. 1971. Permeabilities of Precambrian Onverwacht cherts. Nature 232:325.
64. (a) Schopf JW. 1975. Precambrian paleobiology: problems and perspectives. Annual Review of Earth and Planetary Science 3:213; (b) 1975. The age of microscopic life. Endeavour (I.C.I. magazine) 34:51.
65. See also: Rutten (Endnote 23, p 246) for other possible macrofossils.
66. Barghoorn ES, Tyler SA. 1965. Microorganisms from the Gunflint chert. Science 147:563.
67. Schopf JW. 1970. Biological Reviews 45:323.

68. Eglinton G, Murphy MTJ, editors. 1969. Organic geochemistry. Berlin: Springer-Verlag.

69. Kvenvolden KA. 1975. Geochemistry of amino acids. Annual Review of Earth and Planetary Science 3:18.

70. (a) Abelson PH, Hare PE. 1969. Carnegie Institute of Washington Yearbook 67:208; (b) Kvenvolden KA, Peterson E, Pollock GE. 1969. Optical configuration of amino acids in Precambrian Fig Tree chert. Nature 221:141; (c) Oró J, et al. 1971. Configuration of amino-acids in carbonaceous chondrites and a Precambrian chert. Nature 230:107.

71. Degens ET. 1969. Biogeochemistry of stable carbon isotopes. In: Eglinton & Murphy (Endnote 68), p 304.

72. Pettijohn FJ. 1975. Sedimentary rocks. 3rd edition. NY: Harper and Row, p 588.

73. Carruthers GR, Page T. 1972. Apollo 16 far-ultraviolet camera-spectrograph: earth observations. Science 177:788; see also Snow GE, Javor GT. 1975. Oxygen and evolution. Origins 2:59, for further comments.

# ARTICLES

## ANOMALOUS AGES FOR METEORITE IMPACTS AND TEKTITES

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*Impact craters in the fossil record are intriguing, but even more so is the dating associated with them. The author evaluates some of these data.*

With the advent of the space age and exploration of meteorite impact sites on the moon (Short 1975), an intensified search has ensued for similar impact structures on the earth. In 1968 a list of 52 craters of meteorite or comet impact had been verified, and by 1971 the list had jumped to 62, not including seven others from the U.S.S.R. (French & Short 1968, p 256-257; Millman 1971; Zotkin & Tsvetkov 1970). Subsequent to these listings, reports from Russia called to light the two largest terrestrial craters identified to date, Ishim and Popigay impact structures, with diameters of 350 km and 70-80 km respectively (Masaytis et al. 1972; Zeylik & Seytmurdtova 1974). Very recently the discovery of the world's largest known Quaternary crater was announced (Dietz & McHone 1976). Located in Siberia some 600 km from the nearest recent volcanoes, its nearly perfect circularity 18 km in diameter has been studied both by satellite and ground observation. The catalog of Canadian craters of confirmed meteoritic origin has been brought to 21 with the recent discovery of Haughton Dome on Devon Island (Robertson & Mason 1975). Several U.S. impact structures have been suggested over the years: Meteor (Barringer) Crater, Arizona (Figure 1); Kentland structure, Indiana; Japhtha Knob, Kentucky; Wells Creek Basin, Tennessee; Serpent Mound, Ohio; and Crooked Creek, Missouri (Middlehurst & Kuiper 1963). More recently, similar structures have been identified totally subsurface through drilling operations in the Williston Basin on the U.S.-Canadian border (Sawatzky 1975).

During the 1960s it was sometimes heatedly debated whether such structures were volcanic or meteoritic in origin. The most outstanding proponent of their extraterrestrial origin has been R.S. Dietz, who proposed

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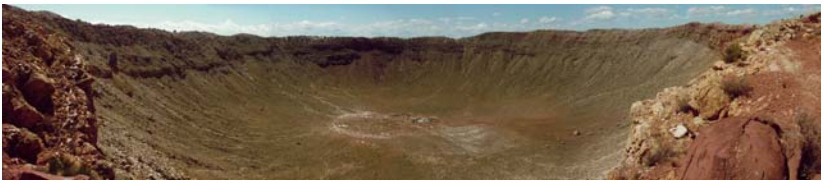

**FIGURE 1. Panoramic view of Meteor (Barringer) Crater near Winslow, Arizona. This crater is 1.26 km in diameter and 174 m deep.**

the term “astrobleme” (star wound), to describe them (Dietz 1963). One of the main proponents of their endogenetic origin was the late Walter Bucher, who identified them as “cryptovolcanic structures” (Bucher 1964).

The true meteoritic (or perhaps cometary) origin of these enigmatic structures has been established on the basis of several criteria. The most obvious criterion is the presence of shatter cones, conical fractures with diverging striations along the length of the cone. Orientations of the cone apices were originally in the direction of the impact object and thus served as indicators of the amount of tilt in the beds subsequent to impact, some beds even overturning (Manton 1965; Howard & Offield 1968). Many shatter-coned astroblemes have been identified since Dietz listed 17 examples (Dietz 1968). While shatter cones are easily visible to the naked eye, other effects of shock can be observed only through microscopic and X-ray studies, such as shock deformation lamellae in quartz (Carter 1965; Engelhardt & Bertsch 1969).

Two other criteria of shock impact are both high-pressure polymorphs of silica, coesite and stishovite, which can be produced in the laboratory only under extremely high pressures and fairly high temperatures (Stoffler 1971). The presence of coesite, which can be formed at pressures of 425-500 kilobars and temperatures near 1000°C, has confirmed the meteoritic origin of Lake Wanapitei Crater in Ontario (Dence et al. 1974) as well as other sites (Cohen et al. 1961). Other specialized types of melted rocks, suevite and pseudotachylite, are also key indicators of meteorite impacts (Dennis 1971; Wilshire et al. 1971).

Lunar exploration has confirmed another unique feature of astroblemes, whether terrestrial or lunar; namely a central uplift area which occurs only in the larger impacts (Cohen et al. 1961). This uplift can be easily observed in such confirmed impact sites as the Wells Creek Basin, Tennessee, where Ordovician strata have been raised 750 m, and the Sierra Madera of Texas, where Permian rocks have been uplifted 1200 m (Wilshire & Howard 1968). Associated with central uplift is the actual forcing of adjacent strata inward and upward accompanied by intense brecciation of the uplift area (Wilshire et al. 1971).

The dating of the meteorite impact events is one of the most intriguing aspects of this study, since it has application in determining the frequency of meteorite impacts both on earth and on the moon (Baldwin 1971). The tremendous pressures (425-500 kilobars with coesite) and the high temperatures (1000°C with coesite and 400° with stishovite formation) result presumably in a resetting of the potassium-argon and the fission-track radiometric clocks.

Examples of the resetting of the clocks are numerous. The Charlevoix structure, Canada, has K-Ar ages of 372 million years (m.y.) and 342 m.y. for impactites and 335 m.y. for pseudotachylites. Impactites and pseudotachylites are unique rock types that are good indices of impact. The rubidium-strontium age of the same rocks is 1280 m.y., suggesting that the Rb-Sr clock was unaffected by the impact (Rondot 1971). Mistastin Lake, Labrador, shows a K-Ar age of 202 m.y. for shocked rocks and 1340 m.y. for an area outside of the shock zone (Taylor & Dence 1969). In Mauritania, the Tenoumer Crater has a vast age gap between shocked and unshocked rocks. The K-Ar ages of unshocked Precambrian basement rocks are 2010, 1770, and 1820 m.y., while the shocked rocks that were melted by impact show K-Ar ages of 2.4, 2.6, 4.2 and 9.2 m.y. (French et al. 1970), a reduction in magnitude of up to $10^3$. The Rb-Sr clock for the same basement rocks reads 2400 and 2440 m.y. while for the shocked rocks it shows slightly reduced ages of 2000 and 1800 m.y.

In rare cases two different radiometric clocks have been reset synchronously. The Gosses Bluff structure, Australia, has the main earmarks of meteorite impact (shatter cones, suevite, quartz lamellae, central uplift). The dating of sanidine, which is argon retentive, in the central uplift region shows a K-Ar age of 133 m.y. (Milton et al. 1972). A drill hole has uncovered Precambrian rocks at the base giving Precambrian ages (greater than 600 m.y.) by the fission-track method, while rock from the baked zone melted by the meteoric impact yielded a fission-track age of 130±6 m.y. (Milton et al. 1972).

In Germany the Ries-Kessel Crater has the key indices of shock (suevite, coesite, shatter cones) as well as the additional evidence of scattered erratics and glass bombs. One erratic block about 1000 kg in weight appears to have been hurled 150 km east of the crater and scattered glass bombs indicate temperatures upwards of 2000°C (Horn 1972). Many such erratic blocks are found along the Pliocene surface outside the crater area proper (Dennis 1971). Concordant K-Ar and fission-track ages of

14.8 and 14.0 m.y. respectively are used to date the impact event. Brecciated Mesozoic rocks (Triassic and Jurassic) are found within the crater while undisturbed upper Miocene rocks fill the basin of the crater up to 300 m deep. According to the current geological time-scale (Harland & Francis 1971, p 33), the upper Miocene began 12 m.y. ago; thus the stratigraphic evidence is stated as correlating remarkably with the radiometric dating of the Ries event.

The confirmed meteorite crater at Gosses Bluff, Australia, indicates upturned Ordovician, Devonian and Carboniferous rocks overlying Pre-cambrian undisturbed rocks. Shock pressures are estimated at several hundred kilobars based upon the presence of the high-pressure polymorphs of silica. In contrast volcanic activity produces pressures of just a few kilobars at the most. For instance the 1956 eruption of Bezymianny was calculated at three kilobars based upon erratics thrown up to 30 km (Milton et al. 1972). The Charlevoix cratering event has shattered Ordovician rocks, which may have been deposited both before and after the event (Rondot 1971). According to the current geological scale (Harland & French 1971), the Ordovician period came to an end 435 m.y. ago, while the mean age of the Charlevoix Crater is published as 380 m.y. The discrepancy is usually attributed to argon escape.

Such findings have dynamic implications from a creationist viewpoint. If these astroblemes as mentioned are indeed the products of meteorite impact (the evidence points in that direction); if the cratering event actually reset the radiometric clocks (the resetting of two independent clocks synchronously seems to suggest this); and if fossiliferous strata were involved in the cratering event (here the evidence is unequivocal), then the creationist is faced with an ultimatum offering two alternatives:

1. He accepts the radiometric readings at face value, and thus he must accept the existence of life for at least as long as 450 m.y., when the oldest confirmed cratering event is said to have occurred in fossiliferous strata;
2. He rejects the usual interpretation of radioactive-age measurements, thus maintaining harmony with the Scriptural view of life extending back only a few thousand years.

Either the radiometric dating interpretations must be in error, or the interpretation of these fossiliferous rocks as products of the Noachian flood is in error. Which alternative is the correct one? We turn to tektites for further information.

Tektites are small glassy objects usually sculptured into distinctive shapes and whose origin has sparked one of the more heated controversies of twentieth-century space science. The glass has been generally ascribed to an impact origin, but it has been debated whether the impact was on earth, on the moon, or on some other planet. The debate was most intense through the 1960's, but the tide turned away from the lunar origin after the Apollo moon landings: "The Apollo lunar missions provide critical evidence which refutes the hypothesis of lunar origin of tektites" (Taylor 1973). Tektites are now firmly linked with terrestrial meteorite impacts which have splashed this molten glass into particular geographical ranges, called strewn-fields. Each strewn-field has provided samples of harmonious composition as well as harmonious radiometric dates (Table 1).

**TABLE 1**

**Potassium-argon ages of tektite strewn fields.**

(Adapted from Barnes VE. 1967. Tektites. International Dictionary of Geophysics 2:1516).

| TEKTITE TYPES | NUMBER OF SPECIMENS | K-AR AGES ($10^6$ yrs) |
|---|---|---|
| Australites | 6 | 0.68-0.76 |
| Bediasites (Texas) | 6 | 33.7-35.0 |
| Georgia tektites* | 3 | 33.7-35.0 |
| Indochinites | 4 | 0.71-0.73 |
| Ivory Coast tektites | 1 | 1.3 |
| Javanites** | 3 | 0.72-0.73 |
| Moldavites (Germany) | 8 | 14.4-14.9 |
| Philippinites | 5 | 0.68-0.73 |

*Includes Martha's Vineyard tektite.
**Includes one billitonite and a specimen from Borneo.

The most clear-cut case of a common origin for an astrobleme and nearby tektites is the Bosumtwi Crater (Ghana) and the Ivory Coast tektites. The presence of coesite, suevite and shatter cones indicates that this is an impact crater (Schnetzler et al. 1966). Glass from the crater itself and from the Ivory Coast strewn-field 300 km to the west shows concordant K-Ar and fission-track ages of 1.3 m.y. (Schnetzler et al. 1966). Samples from both localities also lie on the 1970 m.y. Rb-Sr isochron, while no other tektites — either Australian, European, or North American — lie on the same isochron (Durrani 1971). An analysis of uranium, thorium, and potassium content shows very close correlation between the two areas (Rybach & Adams 1969). Of these Ivory Coast tektites, it is stated that the "identification of these, as derived from the country rocks at the Bosumtwi Crater, appears well established" (Taylor 1973).

The European tektites, known as moldavites, have often been linked with the Ries-Kessel Crater, which has been dated (as noted previously) between 14.0 and 14.8 m.y. Moldavites have a strikingly similar age range of 14.4-14.9 m.y. (Table 1). Chemical analysis of the two areas has failed to turn up a genetic relationship, so that it is now questioned whether moldavites have been derived from the Ries (Taylor 1973). Recent evidence points in the direction of a "swarm" of meteorite impacts at the time of the Ries event, thus linking moldavites with associated craters (Horn 1972).

The Australian tektites, known as australites, have not been linked with any parent crater. In nearby Tasmania another type of glass which is compositionally related to tektites, known as Darwin glass, has now been linked with the Darwin Crater (Gentner et al. 1974). Further search may uncover a source for Australian tektites.

Whereas Australian tektites show concordant radiometric ages clustering around 0.7 m.y. (Table 1), their stratigraphic ages show a far different picture. Edmund Gill, of the National Museum of Victoria, Melbourne, in working the Port Campbell area of western Victoria has uncovered 14 australite samples *in situ* above the hardpan soil zone which has been dated by the radiocarbon method at seven locales, the oldest being 7300 radiocarbon years (Gill 1965). Charcoal from the same level as that containing specimen 9 yields a radiocarbon age of 5700 years. The possibility of transport from an older source area has been ruled out. Since the "Port Campbell australites include the best preserved tektites in the world ... any movement of the australites that has occurred...has been gentle and has not covered a great distance" (Gill 1965). Aboriginal implements have been discovered in association with the australites. A fission-track age of 800,000 years and a K-Ar age of 610,000 years for these same australites unavoidedly clashes with the obvious stratigraphical and archaeological interpretation of just a few thousand years.

A similar study was done on australites from the Lake Torrens Plain, South Australia (Lovering et al. 1972). They are found abundantly and in an excellent state of preservation from the Lake Torrens Formation, which has been carbon dated between 16,000 and 24,000 years B.P. Transport from a nearby Pleistocene source has been ruled out for several reasons. Nearest Pleistocene outcrops are 15-25 km away, and tektites have been found in "modern" sand dunes which are part of the Lake Torrens

Formation, showing that they could not have been washed into a wind-blown deposit. “As the excellent preservation of most of the australites indicates that they have undergone negligible transport since their infall, it is concluded that the australites fell into the dune field sometime between about 24,000 and 16,000 B.P.” (Lovering et al. 1972).

In answer to the suggestion that there could have been two episodes of australite falls, the one recent and the other at 800,000 years, the australite distribution pattern is marshalled as evidence for just one australite fall (McColl & Williams 1970). “Hence, geological evidence from the Australian mainland is at variance, both as to infall frequency and age, with K-Ar and fission-track dating” (Lovering et al. 1972). Commenting on the above findings by Lovering and his associates, the editors of the recent book *Tektites* state that “in this paper they have built an incontrovertible case for the geologically young age of australite arrival on earth” (Barnes & Barnes 1973, p 214).

Based on Australian data, the K-Ar and fission-track dates of all tektites are suspect. Artificial tektite glass with the same chemical composition as natural tektites has been produced in the laboratory with the startling results that the apparent K-Ar ages range from zero to over 1 m.y. (when supposedly the radiometric clock had been reset to zero). “The data indicate that the assumption of complete loss of $^{40}Ar$ may not be completely valid, and that the interpretation of K-Ar dating as applied to tektites may need reevaluation” (Clark et al. 1966). Another study of certain natural tektites shaped like wheels also indicates that a partial resetting of the K-Ar clock must have occurred. Discrepant K-Ar readings are found between the cores and the flanges of the same australites, the flanges consistently suggesting a greater age (McDougall & Lovering 1969). If the K-Ar ages for tektite glass are shown to be unreliable, then could it be that such ages for related meteorite impact events are also not trustworthy?

A look at radiometric dating of particular meteorite craters validates the suggestion of a partial resetting of radiometric clocks, such as the Manicouagan, the W. Clearwater Lake and the Brent Craters of Canada. The. largest astrobleme in the western hemisphere, the Manicouagan-Mushalagan Lakes structure, has been intensely studied and dated by the K-Ar method, perhaps more intensively than any single structure to date (Wolfe 1971). The radiometric ages show a wide scatter, depending on the various points from which the readings are taken. In general the ages of the impact event focus on two points, 210 m.y. and 300 m.y., and the evidence is clear-cut for a meteorite impact origin — shatter cones, pseudo-tachylite, breccias, and a gradation of shock effects with depth — in this

60 km-wide structure. But a closer examination of the ages show that they drop as low as 190 m.y. and reach as high as 371 m.y. for totally shocked rocks. An even wider range is suggested when a single independent reading of 169 m.y. taken independently from the same structure is considered (Wanless 1968). A slightly shocked anorthosite gives an age of 532 m.y. and unshocked anorthosite five miles away gives an age of 932 m.y. The latter would be considered as the reading prior to impact. Fission-track ages of 208 and 36 m.y. were obtained on separate samples (Fleischer & Price 1968), thus indicating a partial resetting of the radiometric clocks. The anomalous figure of 36 m.y. has not been adequately explained, but is dismissed as erroneous.

The W. Clearwater Lake structure offers a similar pattern. The fission-track age of 34 m.y. is distinctly discordant with the two K-Ar ages obtained, 285 and 300 m.y. (Fleischer & Price 1968). It has been suggested that the solution to this discrepancy is that excess radiogenic argon was retained, as is sometimes the case with pyroxenes, in spite of high shock pressures (Bostock 1969). The anomalies between the fission-track and the K-Ar ages occur in both the Manicougan and Clearwater impact structures and both involve a range of $^1/_{100}$ in magnitude.

The Brent Crater, Ontario, is the most revealing, since we now have 34 dated samples from 12 drill holes, thus ranking with the Manicouagan in terms of number of readings (Hartung et al. 1971). Within a narrow 15 m zone the K-Ar ages drop significantly from a 770 m.y. average as found well below the melt zone to a 380 m.y. average next to the melt zone. Ages from within the melt zone itself are generally lower yet, the six samples showing ages of 321, 332, 339, 340, 354, and 414 m.y. The stratigraphic age of the meteorite impact event is lower Ordovician, since middle Ordovician as well as upper Ordovician fossils have been found in a series of *undisturbed* flat-lying sedimentary beds filling the crater bowl (Lozej & Beales 1975). As noted previously, current estimates place the end of the Ordovician at 435 m.y. which does not harmonize with the K-Ar ages of a lower Ordovician impact event ranging between 320-350 m.y. Hydrothermal enrichment of potassium following the cratering event has been suggested to explain the anomalous ages in the melt zone (Currie 1971), but it has been pointed out that there is little evidence for alteration, neither is it likely that sanidine, which is resistant to argon loss, could have been affected by K-enrichment (Shafiqullah et al. 1968). It is strange that the generally accepted date for the Brent cratering event is a minimum of 414 m.y. B.P. (Hartung et al. 1971), a figure which is based on just one sample out of six from the melt zone. The problem of anomalous ages in these Canadian astroblemes can be solved by one common means, and that is retention of excess argon from the older age (770 m.y.) in spite of the high pressures and temperatures involved. The real ages would be much lower than apparent ages. The former should be reduced to only a few thousand years.

Evidence is continually mounting for incomplete loss of argon in igneous rocks, thus inflating radiometric ages far beyond the actual (Hebeda et al. 1973; Dallmeyer 1975; Armstrong et al. 1975). Comparison of nuclear explosion effects with meteorite impacts is indicating also a partial resetting of the fission-track and K-Ar clocks (Fleischer et al. 1974; Naeser & Faul 1969; Hartung et al. 1970). Two different channels of evidence, the one from meteorite impacts and the other from tektites, both unite in a common solution positing a partial resetting of two key radiometric chronometers. By extension it is quite possible that igneous intrusives, such as batholiths and dikes, as well as volcanic lava flows and ash falls, have experienced only a partial resetting of the radiometric clocks. That possibility must be studied.

## SUMMARY

The manned space landings on the moon, the missions of Apollo 11-16, have sparked a keen interest in the study of impact craters, both lunar and terrestrial (Baldwin 1971). This is already becoming one of the most intensely studied facets of lunar exploration, and the earth becomes a convenient laboratory for an understanding of meteorite impact effects (Short 1975). The Apollo missions have spurred a world-wide search for new impact sites as well as the confirmation of suspected sites. The amount of data being amassed is vast (Freeberg 1969). Conclusions reached are bound to have reverberations in creationist circles. One of the most ironic outcomes of the lunar space probe which began as an attempt to uncover the evolutionary origin of the moon is that it has provided data that show the terrestrial evolutionary time-scale to be in serious question. This probe has clearly ruled out the theory of a lunar origin for tektites and has confirmed their terrestrial origin. Major tektite falls in Australia in strata as young as 5700 years old according to radiocarbon dating have called in question both the fission-track and the K-Ar methods of dating which assign these identical tektites an age of about 700,000 years. Impact age anomalies as great as 100-fold for Canadian craters likewise call in question the validity of the K-Ar and fission-track age interpretations and also the associated stratigraphical age. Even with a high energy, high pressure event, such as meteorite impact, the radiometric clocks are in most cases only partially reset.

## LITERATURE CITED


Armstrong RL, Leeman WP, Malde HE. 1975. K-Ar dating Quaternary and Neogene volcanic rocks of the Snake River Plain, Idaho. American Journal of Science 275:225-251.

Baldwin RB. 1971. On the history of lunar impact cratering. Icarus 14:36-52.

Barnes VE. 1967. Tektites. International Dictionary of Geophysics 2:1507-1518.

Barnes VW, Barnes MA, editors. 1973. Tektites. Stroudsburg, PA: Dowden, Hutchinson and Ross, Inc.

Bostock HH. 1969. The Clearwater Complex, New Quebec. Geological Survey of Canada Bulletin 178.

Bucher WH. 1964. Are cryptovolcanic structures due to meteoric impact? Nature 201:251-254.

Carter NL. 1965. Basal quartz deformation lamellae — a criterion for recognition of impactites. American Journal of Science 263:786-806.

Clark RS, et al. 1966. Potassium-argon ages of artificial tektite glass. American Geophysical Union Transactions 47:144.

Cohen AJ, Reid AM, Bunch TE. 1961. Coesite discoveries establish cryptovolcanics as fossil meteorite craters. Science 134:1624-1625.

Currie KL. 1971. Origin of igneous rocks associated with shock metamorphism as suggested by geochemical investigations of Canadian craters. Journal of Geophysical Research 76:5575-5585.

Dallmeyer RD. 1975. The Palisades sill: a Jurassic intrusion? Geology 3:243-245.

Dence MR, Robertson PB, Wirthlin RL. 1974. Coesite from the Lake Wanapitei CERfi Ontario. Earth and Planetary Science Letters 22:118-122.

Dennis JG. 1971. Ries structure, southern Germany, a review. Journal of Geophysical Research 76:5394-5406.

Dietz RS. 1963. Astroblemes: ancient meteorite-impact structures on the earth. In: Middlehurst BM, Kuiper GP, editors. The Moon, Meteorites and Comets. The Solar System, vol. 4, p 285-300. Chicago: University of Chicago Press.

Dietz RS. 1968. Shatter cones in cryptoexplosion structures. In: French BM, Short NM, editors. Shock Metamorphism of Natural Materials, p 367-385. Baltimore: Mono Books.

Dietz RS, McHone JF. 1976. El’gygtgyn: probably world’s largest meteorite crater. Geology 4:391-392.

Durrani SA. 1971. Origin and ages of tektites. Physics of the Earth and Planetary Interiors 4:251-260.

Engelhardt W von, Bertsch W. 1969. Shock induced planar deformation structures in quartz from the Ries Crater, Germany. Contributions to Mineralogical Petrology 20:213-234.

Fleischer RL, Price PB. 1968. Fission track dating of glass from the Manicouagan Crater. American Geophysical Union Transactions 49:272.

Fleischer RL, et al. 1974. Effect of shock on fission-track dating of apatite and sphene crystals from Hardhat and Sedan underground nuclear explosions. Journal of Geophysical Research 79:339-342.

Freeberg JH. 1969. Terrestrial impact structures — a bibliography, 1965-1968. U.S. Geological Survey Bulletin 1320.

French BM, et al. 1970. Tenoumer Crater, Mauritania: age and petrologic evidence for origin by meteorite impact. Journal of Geophysical Research 75:4396-4406.

French BM, Short NM, editors. 1968. Shock metamorphism of natural materials. Baltimore: Mono Books.

Gentner W, et al. 1973. K-Ar and fission track dating of Darwin Crater glass. Earth and Planetary Science Letters 20:204-210.

Gill E. 1965. Quaternary geology, radiocarbon dating, and the age of australites. Geological Society of America Special Paper 84:415-432. Reappearing as: Gill, E. 1970. Age of australite fall. Journal of Geophysical Research 75:996-1002.

Harland WB, Francis EH, editors. 1971. The Phanerozoic time-scale: a supplement. Geological Society of London Special Publication No. 5.

Hartung JB, Short NM, Adams JAS. 1970. K-Ar analysis of rocks shocked by nuclear explosions. Modern Geology 1:279-281.

Hartung JB, Dence MR, Adams JAS. 1971. Potassium-argon dating of shock-metamorphosed rocks from the Brent Impact Crater, Ontario, Canada. Journal of Geophysical Research 76:5437-5448.

Hebeda EH, et al. 1973. Excess radiogenic argon in the pre-Cambrian Avanavero Dolerite in western Surinam. Earth and Planetary Science Letters 20:189-200.

Horn P. 1972. The Ries Kessel, Germany: an example of meteorite impact as a terrestrial geological process. Geoforum 12:91-95.

Howard KA, Offield TW. 1968. Shatter cones at Sierra Madera, Texas. Science 162:261-265.

Lovering JF, et al. 1972. Stratigraphical evidence for the terrestrial age of australites. Journal of the Geological Society of Australia 18:409-418. In: Barnes VE, Barnes MA, editors. 1973. Tektites, p 217-226. Stroudsburg, PA: Dowden, Hutchinson and Ross, Inc.

Lozej GP, Beales FW. 1975. The unmetamorphosed sedimentary fill of the Brent meteorite crater, southeastern Ontario. Canadian Journal of Earth Sciences 12:606-628.

Manton WI. 1965. The orientation and origin of shatter cones in the Vredefort Ring. New York Academy of Sciences Annals 123:1017-1049.

Masaytis VL, Mikhaylov MV, Selivanovskaya TV. 1972. The Popigay meteorite crater. The International Geology Review 14:327-331.

McColl DH, Williams GE. 1970. Australite distribution pattern in southern central Australia. Nature 226:154-155.

McDougall I, Lovering JF. 1969. Apparent K-Ar dates on cores and excess Ar in flanges of australites. Geochimica et Cosmochimica Acta 33:1057-1070.

Millman PM. 1971. The space scars of earth. Nature 232:161-164.

Middlehurst BM, Kuiper GP, editors. 1963. The moon, meteorites and comets. The Solar System, vol. 4. Chicago: University of Chicago Press.

Milton DJ, et al. 1972. Gosses Bluff impact structure, Australia. Science 175:1199-1207.

Naeser CW, Faul H. 1969. Fission track annealing in apatite and sphene. Journal of Geophysical Research 74:705-710.

Robertson PB, Mason GD. 1975. Shatter cones from Haughton Dome, Devon Island, Canada. Nature 255:393-394.

Rondot J. 1971. Impactite of the Charlevoix structure, Quebec, Canada. Journal of Geophysical Research 76:5414-5423.

Rybach L, Adams JAS. 1969. The radioactivity of the Ivory Coast tektites and the formation of the Bosumtwi Crater (Ghana). Geochimica et Cosmochimica Acta 33:1101-1102.

Sawatzky HB. 1975. Astroblemes in the Williston Basin. American Association of Petroleum Geologists Bulletin 59:694-710.

Schnetzler CC, Pinson WH, Hurley PM. 1966. Rubidium-strontium age of the Bosumtwi Crater area, Ghana, compared with the age of the Ivory Coast tektites. Science 151:817-819.

Shafiqullah M, Tupper WM, Cole TJS. 1968. K-Ar ages on rocks from the crater at Brent, Ontario. Earth and Planetary Science Letters 5:148-152.

Short NM. 1975. Planetary geology. Englewood Cliffs, NJ: Prentice-Hall, Inc.

Stoffler D. 1971. Coesite and stishovite in shocked crystalline rocks. Journal of Geophysical Research 76:5474-5488.

Taylor SR. 1973. Tektites: a post-Apollo view. Earth-Science Reviews 9:101-123.

Taylor SR, Dence MR. 1969. A probable meteorite origin for Mistastin Lake, Labrador. Canadian Journal of Earth Sciences 6:39-45.

Wanless RK, Stevens RD, Lachance GR. 1968. Age determinations and geological studies. Geological Society of America Special Paper 67-2.

Wilshire HG, Howard KA. 1968. Structural pattern in central uplifts of cryptoexplosion structures as typified by Sierra Madera. Science 162:258-261.

# ARTICLES

## CAN THE CHRISTIAN AFFORD SCIENTIFIC RESEARCH?

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*The Christian has responsibilities that call for all his time and resources. Some thought-provoking ideas are presented on the appropriateness of spending some of these precious resouces on scientific research.*

Urgency is the keynote of the Christian's life. Before him is the high goal of restoring the image of God, and, in the background, the ever-present uncertainty of life itself. His responsibility to others is outlined in the Master's commission and his time scale is shortened by fulfilling prophecy. With such a challenge before him, can the Christian afford to spend time and resources on scientific research?

I would like to suggest a positive answer to this question: exploration of the natural world is not out of character with the Christian perspective and the eschatological event. Before listing some reasons, however, a word of caution is in order. Anything said in defense of research is not meant as a.blanket justification for any research done by any person in any circumstance. For the Christian (as for anyone), time and resources should be spent on research only when there is a reasonable expectation of some return on the investment, whether the return be in the form of a practical benefit for mankind or the more esoteric fulfillment of the desire to explore and create. The following discussion is an attempt to list some of the positive factors that a scientist who is a Christian might take into account. One or more of these factors might be applicable in a specific instance.

The word "research" suggests different things to different people. One thinks of a term paper made up of quotations gleaned from library sources while another pictures a massive laboratory filled with gleaming instruments. When the word "research" is used here, it will be taken to mean a systematic investigation of the natural world at any level from sub-nuclear particles to galaxies or from single-celled organisms to human societies. Such an investigation usually combines planned observation with a theoretical synthesis and aims for an understanding of complexity at one level in terms of more familiar ideas at another level. This discussion will be limited to scientific research simply because justifications in this area are less likely to occur to a layman; research in theology or archaeology is not as prone to be misunderstood. The discussion will also exclude development of technology. The Christian might have need for this as well, but the rationale for it is usually quite different from what will be presented below.

First on the practical Christian's list of scientific needs undoubtedly would come those specific areas where he has a different viewpoint or approach, one that is not likely to be pursued by others. Two examples that immediately spring to mind are the history of the earth and the principles of healthful living. Majority opinion in some of these areas (e.g., the origin of man) occasionally is strongly opposed to the Christian's view. This is surprising only so long as one persists in the myth that all scientists are completely objective in their pursuit of knowledge. To organize facts without bias is a worthy goal, but one that is, in fact, rarely achieved. A scientist's beliefs influence not only his theories, but his methods and even his observations. Since the majority of scientists work from a non-Christian perspective, it is to be expected that this majority will occasionally tip the balance of "evidence" against the Christian view. Thus the Christian has a positive responsibility to work from his own viewpoint (with the same goal of objectivity) to provide balancing facts and syntheses. Is it reasonable to ask a non-Christian for a Christian commitment when balancing evidence has not been provided?

Christ's commission to "go into all the world"[1] undoubtedly refers not only to geographic coverage, but to various social and intellectual strata as well. It is an established principle that a person is influenced most strongly by someone similar to himself in age, education and general interests. Thus, one reason that the Christian might well devote some of his energies to scientific research is that he sees scientists as a group who need the gospel, and he wants to be in the best possible position to communicate with them. The habit of constantly being critical (in the best sense, we hope) of new ideas gives scientists the appearance of being intellectual snobs. In fact some are, but more often it is because scientists are used to responding to an appeal from logic and evidence. One who is familiar with this process is best able to present a knowledge of God and His plan for man in a way that will appeal to minds of similar training.

The Christian systems of education often include scientific subjects at all levels from primary to graduate school. It is true that the goals are somewhat different than for similar instruction in other schools, but there is no reason why the quality should not be as high or higher. Teachers who lead students through the dense forest of facts and techniques must have more to offer than simply having read through a new textbook ahead of their students. Particularly at the upper levels, the teacher should be on such familiar terms with his field that he can organize the facts and ideas in the way that will best meet the needs of a particular group of students. Active participation in creative thinking is the best (and virtually the only) way to keep the teacher "alive" for his students. A single intensive experience during graduate school is not sufficient for a lifetime, either to provide information in depth and breadth or to maintain the stimulus of learning itself. All too frequently an advanced degree becomes the end of learning when it is meant to be only the "commencement."

For a person who believes in creation and in a continued close relationship between creation and Creator, one of the positive aspects of research is the knowledge that study of the creation is in reality study of the Creator Himself. It is through the combination of nature and revelation that we have the complete picture of God. Such divine characteristics as unfailing dependability and the exercise of creativity circumscribed by principle are readily apparent to a person who pursues nature's secrets.

So far, the discussion has centered around the results obtained from research. The next positive factor, and in my mind the most important, has to do with the process itself. An oft-cited quotation from the well-known book *Education* reads: "Every human being, created in the image of God, is endowed with a power akin to that of the Creator — individuality, power to think and to do.... It is the work of true education to develop this power, to train the youth to be thinkers, and not mere reflectors of other men's thought."[2]

How, exactly, do you train a person to be an independent thinker? Every part of the body responds to exercise by increasing in capability, and the mind is no exception: the capacity for independent thought increases as independent thought is practiced. In very specific terms, three steps are involved: recognizing a question or problem, solving it by the application of general principles, and finally testing the solution to evaluate its worth. A person can be described as "not a mere reflector" if he can find solutions without directly copying someone who has gone before. Such independence does have its limits; independence from God and complete independence from other men in all circumstances is not justified. There is a time for cooperation and for learning from others, but there is also a need for individuality and independence.

While the sentences quoted above are often used (and rightly so) in the context of religion, the principle applies to the study of nature as well: "Instead of confining their study to that which men have said or written, let students be directed to the sources of truth, to the vast fields opened for research in nature and revelation."[3] In the study of nature, research is the ultimate exercise and test of the capability for independent thought. The researcher pits his powers of logic and organization against the very facts themselves, much as a tracker follows a faint trail through an unknown wilderness. Any mental laziness or other indiscretion sooner or later is exposed by the arrival of more information. The experience of discovery is a powerful reward for the effort expended, one that is not easily described to a person who has not experienced it. Textbook problems are good practice, but knowing that the answers are in the back of the book or in some teacher's key takes the keen edge off both the challenge and the reward.

If the capacity for original thought is a characteristic of the Creator, then it must be that those who are striving in all ways to be like their Creator should be the most capable of imitating Him in this respect. Careful attention to the principles of physical and mental health, for example, should give the mind the best possible chance to develop. The humble and realistic evaluation of one's own capabilities (in comparison with other men and with the Creator) which is essential in the Christian pattern can prevent the most frequent downfall of gifted men — pride. The Christian will recognize that the worth of research is not measured in grandeur of apparatus or abstractness of theory, but in the quality of effort it calls forth from the mind.

Yes, the Christian may very well have time for research. Because of his sense of urgency and because he considers all his resources as valuable gifts and not to be wasted, the Christian will be more careful about his reasons for research. Its pursuit will not be for selfish gain, but that through it he might grow to serve more fully. When kept in correct balance with other aspects of life, it can help him restore his Creator's image and demonstrate it to a world in need.

## ENDNOTES

1. Matthew 28:19.
2. White EG. 1952. Education. Mountain View, CA: Pacific Press Publishing Association, p 17.
3. Ibid.

# NEWS AND COMMENTS

## THE THIRD NATIONAL CREATION SCIENCE CONFERENCE

The Third National Creation Science Conference met on the campus of Northwestern College, St. Paul, Minnesota, August 15-18, 1976. Sponsored by the Bible Science Association of Caldwell, Idaho, and the Twin City Creation Science Association of Minneapolis, it attracted participants from all over the United States and as far away as Australia. Attendance was greater than even its organizers had expected.

Structured around the theme of creationistic research, its speakers presented papers on a wide range of creation-oriented topics. Many of the talks displayed well thought-out reasoning and research. As Duane E. Long in his paper, "Effective Creationist Research," pointed out "If creation science does not read like good science by conventional standards, it is not likely to get a hearing no matter how correct it is." Only in this way can the creationist reach the individual who is sincerely and honestly seeking for truth.

The Conference brought together much careful thinking and research. The large number present shows the interest the creation option is generating. But one facet of the Conference could have disturbing implications. Discussing ways to strengthen creation research, Duane Long stated, "We need specialists organized into review boards to constructively criticize creationist material about to be published." This would parallel the editorial policy of any reputable scientific journal. Perhaps this lack of qualified review was the greatest weakness of the Conference. There should have been more screening of some of the material presented.

A decidedly minority viewpoint today, creation has a hard time getting a hearing. A creationist can easily sympathize with those who hold other little-known or unpopular concepts. But good creation research, even more than other sciences, should uphold the highest standards. It cannot support every idea seeking an audience. Creationists must review and screen what they present, lest it bring question or reproach to their position.

A number of those in attendance at the Conference were overhead to voice concern about a few of the papers. The concept of a geocentric universe particularly disturbed them. One individual stated to those with him, "I don't want to be identified with the Flat Earth Society." Others left the meetings on the topic expressing puzzlement.

True, one does not want to have a closed mind. But with the large body of evidence for a heliocentric solar system (the whole space program of interplanetary probes is based on it), and seeing no threat in interpreting certain Biblical passages as “point of observer” viewpoints, one finds it hard to see why he should throw the creationist position into needless controversy by linking it with the geocentric universe theory. Sin has made the earth the focus of heaven’s attention, but that does not mean it is the physical center of the universe.

Several speakers at the Conference also questioned the reality of large-scale glaciation after the Genesis flood. They attempted, perhaps through the lingering influence of the late George McCready Price, to relegate glacial evidence to the final stages of the flood. The time implications of continental glaciation are admittedly difficult to resolve, but will identifying moraines, drumlins, and other features as giant ripple effects solve the question? A geologist looking at figures in the Conference’s *Proceedings* would perhaps interpret the hills in central to eastern Washington as giant ripples, but he would also probably relate them to glacial activity — the sudden draining of a glacial lake on the Columbian Plateau through the Grand Coulee. Such an event could easily fit into a flood model.

The Third National Creation Science Conference offered much excellent material, but the creationist movement must set and follow the highest scientific standards and screen out questionable or needlessly controversial material if it is to gain the attention and full respect of sympathetic non-creationists. Creationists must do only the very best research.

Gerald Wheeler

# NEWS AND COMMENTS

## CONFERENCE ON THE ORIGIN OF LIFE

The Third College Park Colloquium on Chemical Evolution was held September 29 to October 1, 1976, at the University of Maryland. Under the direction of Dr. Cyril Ponnamperuma the colloquium attracted interested scientists from many parts of the world. A.I. Oparin of the Bach Institute of Biochemistry in Russia, considered the father of the chemical evolution theory of the origin of life, delivered the opening address, "The Problem of the Origin of Life in a Cosmic Context."

Of special interest was a preliminary report of the Mars Viking Lander "Life Detection" (biology) experiment and the gas chromatography-mass spectrometer (GCMS) experiment search for organic compounds on the surface of Mars. The "Life Detection" experiment actually consisted of three separate experiments in which aliquots of martian soil were treated in different ways to detect possible biological activity of organisms in the soil.

To the surprise of some of the investigators, the results of the biology experiments on Mars were positive, and the initial feeling among many scientists was that life had been found on Mars. The comment was made that if the same results had been obtained on a terrestrial soil, there would have been unanimous agreement that living organisms had been detected. However, the crucial experiment using the GCMS failed to detect any organic compounds in the martian soil.

Evidently carbon is only present as carbon dioxide in the martian atmosphere. On terrestrial soil samples, positive results on the biology experiments were always accompanied by the detection of organic matter in the soil by GCMS. Lack of confirmation by the GCMS experiments raised doubts about the presence of living organisms in the martian soil and led to a number of plausible suggestions that inorganic chemical reactions, such as the presence of peroxides in the soil, could have given the "positive" results of the biology experiments.

Two full days of presentations covered such diverse topics as "Composition of the Cores of the Terrestrial Planets," "Properties of the Primitive Solar Nebula," "Volatile Outgassing on Earth and Mars," "Water in the Martian Regolith," "Possible Chemical Reactions on the Surface of Mars," "Precambrian Molecular Fossils," "The Asymmetric Photolysis of DL-Leucine," and "Prebiotic Oligonucleotide Formation."

In spite of the attempt to put the field of chemical evolution on a firmer experimental base, it continues to be highly speculative.

# 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.*

## ONE SIDE OF THE QUESTION

HOW LIFE BEGAN. Roy A. Gallant. 1975. NY: Four Winds Press. 214 p.

*Reviewed by R. H. Brown, Director, GeoscienceResearch Institute*

Individuals who wish to understand the full range of viewpoints in the resurgence of interest in creationism may expect to find this book worth careful study. The author begins by pointing out man's deep-rooted need for an explanation of origins and the evidence that many people are time-haunted. He makes a significant observation that "Man's remarkable talent for inventing myths is surpassed only by his ability to believe in them" (p 8). This is an observation which the reader will do well to keep in mind throughout his study of the book.

One of the more valuable features of *How Life Began* is its summary of creation myths. In this summary the author takes the position that Hebrew ideas of creation and a universal flood were obtained from the Babylonians (p 47), that the book of Genesis was written in the middle of the *first* millennium before Christ (p 37), that the author of the first chapter of Genesis intended the entire universe to be included in the events portrayed there (p 37, 40), and that the second chapter was written approximately 350 years *earlier* than the first chapter (p 42).

With only a casual reading it is apparent that Mr. Gallant has based this book on the philosophical premises that characterize current anthropology and geology. According to his understanding, Copernicus contradicted the Bible regarding motion of the earth (p 66), and religious faith prevented many 19th-century scientists from reasoning objectively and correctly interpreting the fossil record (p 105). He speaks of "the unmistakable sequence of events that Darwin could read in the fossil record" (p 138).

Pages 165-170 contain a valuable analysis of the situation with respect to teaching creationism in the public schools.

The approach to radiometric dating that is taken by many contemporary proponents of creationism is described as similar to the long-discredited view of fossils presented by P.H. Gosse in *Omphalos* (p 185). Such treatment of radiometric dating may be considered as the Achilles heel of a creation movement which utilizes it.

The author of *How Life Began* seems to rely on quotations from the distinguished geneticist Theodosius Dobzhansky to express his own basic viewpoints. Two examples may be cited:

> *'Evolution as a process that has always gone on in the history of the earth can be doubted only by those who are ignorant of the evidence or are resistant to evidence, owing to emotional blocks or to plain bigotry ....There are no alternatives to evolution as history that can withstand critical examination'* (p 150-187).
>
> *'The organic diversity becomes reasonable and understandable if the Creator has created the living world not by caprice but by evolution propelled by natural selection. It is wrong to hold creation and evolution as mutually exclusive alternatives. I am a creationist and an evolutionist Evolution is God's, or Nature's, method of Creation. Creation is not an event that happened in 4004 B.C.; it is process that began 10 billion years ago and is still under way'* (p 186, 187).

Some readers will see this book as a skillful attempt to neutralize efforts to introduce creation into the public-school curriculum, particularly a creation viewpoint that is based on the first portion of the book of Genesis. While the treatment given by Mr. Gallant is brief and severely limited with respect to the broad range of evidence and issues involved in the treatment of origins in public schools, it makes a helpful contribution toward understanding the thinking of an influential segment of our society on this complex topic.

# 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.*

## GEOLOGICAL CHANGES AND TIME

ON THE SURVIVAL OF PALEOFORMS. C. R. Twidale. 1976. American Journal of Science 276:77-95. THE TEMPO OF GEOMORPHIC CHANGE. Maxwell Gage. 1970. Journal of Geology 78:619-625.

*Reviewed by Ariel A. Roth, GeoscienceResearch Institute*

The question of the amount of time required for geological changes is of considerable interest to those concerned about various theories of origins. Evolution needs all the time possible to increase the probability of unlikely events, and proponents of creation propose much shorter periods than those suggested by the standard geological time scale. The two papers considered here address themselves to questions of rates of geological change; hence are of great interest.

The first paper by Twidale entitled "On the Survival of Paleoforms" is the more comprehensive and technical of the two. It considers the question of the survival of some ancient topographical features of the past which according to several standard interpretations should have disappeared. These are referred to as paleoforms. The author discusses especially flat plain-like features that have a low relief; however, more irregular features are not ignored. Ancient plains recently exhumed by erosion do not, in Twidale's opinion, pose a problem, since their overburden protected them in the past from the erosion that might have destroyed them. However, this is not the case with those plains which appear to have been exposed to weathering for long periods of time, yet have survived. He states:

> *Even if it is accepted that estimates of the contemporary rate of degradation of land surfaces are several orders too high (Dole and Stabler, 1909; Judson and Ritter, 1964; see also Gilluly, 1955; Menard, 1961) to provide an accurate yardstick of erosion in the geological past, there has surely been ample time for the very ancient features preserved in the present landscape to have been eradicated several times over. Yet the silcreted land surface of central Australia has survived perhaps 20 m.y. of weathering and erosion under varied climatic conditions, as has the laterite surface of the northern areas of the continent. The laterite surface of the Gulfs region of South Australia is even more remarkable, for it has persisted through some 200 m.y. of epigene attack. The forms*

*preserved on the granite residuals of Eyre Peninsula have likewise withstood long periods of exposure and yet remain recognizably the landforms that developed under weathering attack many millions of years ago.*

Later he states: "The survival of these paleoforms is in some degree an embarrassment to all of the commonly accepted models of landscape development."

Twidale then proceeds to point out the inadequacies of the commonly held models of landscape development and proposes alternative ideas which may help explain the survival of these paleoforms. He suggests that rivers have a strong local influence on erosion and that paleoforms which happen to be between them are not eroded away as fast as the river beds themselves. This results in a tendency to increase relief with time. This idea is contrary to the generally accepted view that landscapes tend to become flatter with time. Other factors which the author feels contribute to the survival of paleoforms are the greater hardness of the rocks, protection from weathering effects in elevated areas compared to low-lying ones and several complex phenomena associated with erosional processes. The paper concludes by proposing a model "characterized by persistent and increasing relief" where the paleoforms are preserved while deeper erosion proceeds between them.

In the reviewer's opinion, Twidale's ideas make the generally accepted model for the formation of peneplains all the more difficult to accept. Peneplains are extensive plains of the past. Usually they are buried in the rocks that form part of the crust of the earth and are supposed to be the results of long-term erosion producing a near-flat surface. They are quite common in some sedimentary deposits, but their mode of origin has been much debated. If, as Twidale suggests, time increases relief patterns, the presence of extensive flat-like peneplains in ancient sediments may well represent features where little or no time for erosion has occurred, having been buried rapidly after deposition. This is a concept which Twidale and most other geomorphologists might vigorously reject.

Twidale's paper is particularly gratifying because he shows an unusual degree of independent thought, being quite free to challenge well-established concepts. His models are based on a thorough knowledge of field relationships; he has published extensively in this area.

The second paper entitled "The Tempo of Geomorphic Change" by Maxwell Gage also challenges some established geological concepts. The author feels that it is dangerous to extrapolate present-day rates to the past. He emphasizes significant variability in rates of change. Like Twidale he mentions very stable geomorphic features in South Australia which have survived since post-Paleozoic time (presumably several hundred million years). In contrast to this, some rivers on the steep western slopes of the Southern Alps appear to be eroding their watersheds at a rate of 0.1 inch per year. If one extrapolates this figure back in time over a period of 10 million years, one would get 25 kilometers of erosion. Such conclusions would not be compatible with standard geological interpretations. Mention is also made of the Waiho River in New Zealand which during a single high intensity rainstorm elevated its bed from 10 to 80 feet over several miles. During the succeeding few weeks, rapid downcutting produced a flight of 10-foot terraces. Referring to these and other terraces, he states:

> *Colonized rapidly by plants in this moist temperate region, they soon acquire a false aspect of antiquity and in another environment might be mistaken for late Pleistocene degradational terraces.*

The next section in Gage's paper presents a variety of relationships between time and geomorphic change. He rejects the extremes of a rectilinear relationship as well as instantaneous change, characterizing the latter as "absurd." He opts for some kind of incremental pattern. He recognizes the importance of catastrophism, pointing out that the concept "has received perhaps less attention than it deserves"; however, he favors a model that gives greater importance to "smaller, cumulative changes." He concludes by steering a course between classical uniformitarianism and catastrophism, stating:

> *The uniformitarian approach may appear not to measure up to the requirements of quantitative work; yet it would be unjust to consider this doctrine invalidated merely because of difficulties due to our inadequate knowledge of the essential link between present and past.*

Both these papers raise some thought-provoking ideas. The writers exhibit a great deal of confidence in the standard geological time scale; yet if this were not accepted as sacrosanct, the concepts presented could serve as a strong basis for questioning its validity. Why have some paleoforms survived many times longer than expected? If variation in tempo in geomorphic change is so common, is it sound to extrapolate the present into the past? Unfortunately the proposed explanations given are not quantitatively evaluated and are not very useful in answering the time questions raised in this review. The scientific data of both papers indicate that much greater caution is warranted in approaching questions regarding the length of time involved in the past history of the earth.

# GENERAL SCIENCE NOTES

## HOMOLOGIES

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There is a wide variety of animals, representing many different types of structures, from one-celled protozoa to the most complex animal — man. There are animals with skeletons inside their bodies and some with skeletons on the outside. Some lay eggs and some bear live young; some are cold-blooded and some are warm-blooded. Within each group there are many species, each a little different from the others. For example, there are about 1200 species of rats and mice in the entire world. Some of those species are so similar that it is difficult to tell them apart, but each one is different in some way, and each species does not normally interbreed with any of the other species. Zoologists arrange these animals in a standard classification scheme, beginning with the simplest one-celled organisms and ending with man. In this classification system each type of organism is placed next to those that are most similar to it.

The study of homologies plays an important part in determining which organisms should be classified close together. When two animals have body parts that are alike in their basic anatomy and develop along the same growth pathways when the animals are embryos, these similar body parts are referred to as homologous parts. Consider the arrangement of the bones in the forelimb of a man, a seal, a bat and a dog. Humans have hands that are very agile for manipulating objects; seals' flippers are useful only for swimming; bats have wings for flying, and dogs' feet are built for fast running. They all look very different, yet they have the same basic arrangement of bones. Only the proportions of the individual bones and the type of fleshy covering are different. A bat's wing bears little resemblance to a human hand, and yet the wing membrane is supported by a skeleton that is equivalent to our second, third, fourth and fifth fingers, but with very elongated finger bones. The creation theory proposes that the vertebrate limb was designed to be an efficient and adaptable structure, and then the same basic design was used for all of the vertebrates. Only minor modifications, mainly in proportions and in the type of fleshy covering, were needed to adapt this skeleton to the needs of each animal.

These different types of limbs are homologous, indicating that seals, bats, dogs and men should be classified in the same group of animals.

However, according to the evolution theory, the fact that these animals all have homologous limbs is considered to be evidence that they have all evolved from common ancestors. It is often believed that they would not have homologous limbs unless they had inherited them from common ancestors. However, these homologies are also what we would expect to see if the vertebrates had all been designed and created according to a common vertebrate body plan. Consequently, homologies in anatomy are not really evidence for or against evolution.

There are also homologies in physiology, biochemistry and embryology. The principles are the same in these fields as for homologies in anatomy. Similarities in physiology or similar developmental pathways in embryos are often considered to be evidence of evolution from a common ancestor, but they are also what we would expect to see if all life was created by a single intelligent Designer. Also in the biochemical structure and functions of cells, there are many features that are virtually the same through the animal and plant kingdoms. For example, all living things, both plants and animals (excluding some viruses), have chromosomes containing DNA. This DNA contains the genetic code that determines the entire structure and physiology of the organism. The basic details of this mechanism are the same in all living things. This is considered by some to be evidence that all living things evolved from a common ancestor, but we can also consider it to be evidence that all living things were designed by one intelligent Designer who used the same exquisitely designed genetic mechanism for all.

The details of the evolution theory of the history of life are based largely on these homologies between organisms. All plants and animals are arranged in the classification system with the simplest ones first, and then more and more complex organisms. Those who accept the evolution theory believe that this arrangement is the order in which the animals evolved, from simple to complex. Organisms with the most similarities, or homologies, are placed closest together in the classification system. From this classification scheme, phylogenetic trees are constructed. Phylogenetic trees are diagrams representing the presumed evolutionary pathways along which organisms have evolved.

If we would compare many different types of wheeled vehicles, we would find that they also have many homologous parts and that they can be arranged in a sequence based on these homologies. For example, they all use the principle of the wheel. Most of them also use levers in some way, and several use energy produced by the internal combustion of fuel. Using this information, we can construct a “phylogenetic tree” by following the same principles used in making an animal or plant evolutionary tree. Of course no one would say that this means that cars evolved from two-wheeled carts. The different vehicles have homologous parts because they were all designed to operate under the same natural laws. Certain design concepts are used in several different vehicles and adapted to meet the different functional requirements of each one. They can be arranged in a sequence of simple to complex because they all are designed to serve different functions, and thus their structural requirements are quite different. The result is a wide diversity of types, differing in structural complexity, and each well suited to perform its unique function.

When we apply these same principles to living things, we can develop an interpretation that is consistent with both the biological data and the concept of creation. Hence one of the most commonly used arguments for evolution utilizes data that are not especially supportive of the theory, but fit equally well the concept of creation.