EDITORIAL

THE SEARCH FOR AN EVOLUTIONARY MECHANISM

Evolution as a plausible explanation for the origin of all living organisms has received serious consideration for at least two centuries. During this period there has been an intensive search for a mechanism that could create the complex from the simple. Changes in nature usually tend towards randomness and not towards making special structures and systems as needed for evolutionary advancement. This process of increasing complexity in design mandates some kind of unusual mechanism. Evolutionists have proposed many. A brief review of the dominant ideas is instructive.

1. Lamarckism

At the beginning of the 19th century the French biologist Lamarck advanced what is usually considered to be the first serious proposal for an evolutionary mechanism. He suggested that use of an organ would cause it to improve, and this improvement would be passed on to the next generation. Thus, a deer-like animal could eventually evolve into a giraffe by persistent stretching of the neck. His ideas are not given serious credence at present, except for a few special cases.

2. Darwinism

About half a century later, Charles Darwin and Alfred Russel Wallace in England suggested that evolution advanced by a combination of variation and survival of the fittest. Continual natural selection of the fittest produced advanced forms. Darwin stressed the importance of small changes. He put forward a new mechanism for the inheritance of newly acquired characteristics. His model of reproductive cells contained "gemmules" which came from all over the body and passed on the new characteristics to the next generation. Darwin's idea of survival of the fittest, while severely challenged, is still given serious consideration. His idea of gemmules is not.

3. Mutations

Prominent among the detractors of Darwin was Hugo de Vries in Holland who, around the turn of the century, suggested larger evolutionary changes called mutations. He considered these to be the significant evolutionary process, in contrast to Darwin's smaller changes. While the interpretation of his experiments turned out to be largely erroneous, real mutations were discovered later by F. H. Morgan. Unfortunately for the evolutionary viewpoint, these changes turned out to be overwhelmingly

detrimental. Some evolutionists still stake their hopes on the potential of a few beneficial mutations.

4. Population Evolution

Early this century, R. A. Fisher in England and Sewall Wright in the United States developed sophisticated mathematical models of evolution that helped shift the emphasis of an evolutionary mechanism from individual organisms to populations. Fisher emphasized small changes in large populations. Wright wanted smaller populations to facilitate the manifestations of new mutations, but not so small as to engender the deleterious effects of inbreeding. The question of proper population sizes for progressive evolution is still debated.

5. Modern Synthesis

The modern synthesis is a vague combination of the mutation concept and Darwin's idea of survival of the fittest. It has been championed by many leading evolutionists during the middle of this century, including Julian Huxley, the grandson of Darwin's promoter Thomas Huxley. The modern synthesis did not remain long as a synthesis, although it still has many adherents. Numerous problems developed, including questions about population sizes and especially how random mutational changes could produce the large changes necessary for new organs and systems. These changes seemed to require a very complex correlation of mutations or some kind of survival value through awkward intermediate stages. For instance, in the evolution of the forelimb of a reptile into the wing of a bird — assuming birds evolved from reptiles —, one must postulate either all kinds of correlated changes occurring simultaneously to produce a wing, or intermediates which were neither good limbs nor good wings but would be able to survive. Both postulates seem quite unworkable.

6. Diversity Period

After the modern synthesis, the plot for evolution has thickened considerably due to new information and a number of disputes that persist to the present. The current status of evolutionary mechanisms can best be characterized as both diversified and controversial.

Among the current debates are: (a) the traditionalist-cladistic debate over what kind of characteristics are significant in determining evolutionary relationships (the cladists appear to be winning), (b) the gradualist-punctuationalist debate over whether to expect evolution to proceed by smooth gradual changes or small jumps, (c) the neutralist-selectionist debate over neutral versus meaningful mutation and the consequent significance of natural selection acting on these.

Adding to the diversity of the present discussion are new discoveries in molecular biology that make the older idea of simple random mutations in a genetic system inadequate as a workable theory of origins. For instance: (a) How could the process of protein synthesis evolve when DNA is needed to produce proteins, and proteins are needed to produce DNA? (b) How does one originate a transfer of information through the genetic code by random changes? In this system three of four different kinds of molecules (nucleotides) are coded in a specific order for each of 20 different amino acids. It is difficult to imagine how a meaningful coded system could originate by random process. (c) How could the efficient antibody-producing system arise by random changes? In this system a few hundred genes can produce many millions of different kinds of antibodies. (d) How could the accuracy needed for DNA replication occur before the evolution of the correcting processes? Without enzymes, around 1% error occurs in DNA synthesis, spelling disaster for maintaining complex biochemical systems. With complex correcting systems in operation, the duplication of DNA is millions of times more accurate. How did these correcting systems evolve without correcting systems to maintain their consistencies?

Much more could be added, and various scenarios have been proposed by evolutionists, but it now appears that we are dealing with complex systems that represent information processing and reprogramming functions that can purposefully relocate genes or parts thereof. Because of this the requirements for an evolutionary mechanism are much more complicated than was conceived earlier. According to our present understanding, progressive evolution is more comparable to a mechanism that would spontaneously generate a working computer. However, this would not be an ordinary computer; to match reproduction in living organisms this computer would have to reproduce more computers like itself and then evolve into more and more advanced computers.

Two centuries of search for a naturalistic mechanism for evolution have not provided a workable model. In fact, recent findings indicate that the goal seems more elusive than ever. Is it not time for evolutionists to give serious consideration to other alternatives — such as creation?

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: Brown & Webster: Interpretation of Radiocarbon and Amino Acid Age Data (ORIGINS 18:66-78)

I read with interest Brown and Webster's article on the problematic relationship between the ^{14}C chronology and amino acid racemization dating. I am unable to evaluate the technical aspects of the paper but wish to comment on two other issues.

First, it seems the authors pushed the implications of their data too far. They suggest that the disagreement between expected (on theoretical grounds) and observed (based on the ^{14}C chronology) rates of racemization "compounts [sic] the uncertainty in using amino acid isomer ratios for age determination, and also brings radiocarbon ages beyond 4,000 BP. into question" (p 66). How can it do both? The uncertainty in amino acid dating is only compounded if one assumes that ^{14}C time equals real time (which the authors do not assume), whereas ^{14}C dating is only brought into question if one assumes that racemization rates really behave as the authors expect them to. These assumptions appear to be mutually incompatible given the available data.

Second, the authors suggest that the Ice Age (continental glaciation) occurred between 2,800 and 4,200 B.P., but this is inconsistent with their own model for converting ^{14}C to "real" time. The oldest ^{14}C date used in this paper (10,400 B.P.) falls at or after the end of the Ice Age (the Ice Age ended ca. 11,000 B.P. based on ^{14}C dates) and is converted to a "real time" estimate of 4,765 B.P. (Table 1). Thus, according to their model, the Ice Age must have *ended* by about 4,800 B.P. and could not have extended between 4,200 and 2,800 B.P. The latter period is characterized by low racemization rates in their Fig. 6, and cooling could not have been the result of the Ice Age.

H. Thomas Goodwin
Section of Paleontology, Department of Natural Sciences
Loma Linda University, Loma Linda, California

Brown & Webster's reply:

The disagreement between amino acid racemization age estimates and corresponding radiocarbon age determinations reinforces uncertainty regarding the significance of an age determination by amino acid racemization ratios. Additional questions are also raised as to how reliable ^{14}C age determinations may be as a standard against which amino acid age determinations may be judged. Whenever two witnesses disagree, it is necessary to make a decision whether one or both are inaccurate.

We probably should have taken greater care to explicitly state that in reference to glaciation and the ice age we were dealing only with the effect on climate in southern Palestine (p. 76, ¶ 2) and northeast Africa (p 77, ¶ 1).

Hopefully the interpretations we have suggested will aid in worldwide climate modeling that treats the 11,000 B.P. conventional ^{14}C date for the end of glacial advance in northern Europe and North America.

ARTICLES

COSMOLOGY AND GENESIS: THE ROAD TO HARMONY AND THE NEED FOR COSMOLOGICAL ALTERNATIVES

Mart de Groot
Armagh Observatory
Armagh, BT61 9DG Northern Ireland

WHAT THIS ARTICLE IS ABOUT

The current scientific picture of the origin of the Universe seems at odds with the Genesis account. Is this a serious problem for those who believe the latter to be reliable? Are there ways to harmonize the two? Or should we be looking for alternatives to the so-called Standard Model for the origin of the Universe? This article presents some thoughts that suggest answers to the above questions along the following lines: most of the apparent problems can be solved by realizing that the so-called Standard Model has weaknesses and allows other models and other interpretations; on a number of scores the two accounts can be harmonized, because both leave enough room for accommodating a wider view; on other scores harmony seems impossible, and there is a need for considering alternative cosmologies, especially creation by God.

INTRODUCTION

This article begins with a short discussion of the measurement of long time-scales, followed by a review (Section 3) of the main characteristics of the Standard Hot Big Bang Model. Weaknesses in the Standard Model are discussed in Sections 4 to 7; matters that seem to point to an intelligent design in Sections 8 and 9; scientific ideas about the very beginning of the Universe, i.e., what happened before the time specified in the Standard Model, in Sections 10 and 11. Further reasons for investigating alternatives are summarized in Section 12, and one particular alternative, creation by God, is discussed briefly in the Conclusion.

1) THE MEASUREMENT OF TIME

Astronomers have conclusively shown that the Universe by any standards is very large. Yet, here is tiny man on a rather small planet orbiting a not particularly impressive star. That star, our Sun, is one of some 100,000 million in our Milky Way Galaxy — a galaxy of which there are about as many as there are stars in our Milky Way. This tiny human on this tiny planet has constructed instruments which allow him to study such a large Universe almost as far as it stretches. As our knowledge of the Universe reaches out to farther and farther objects, it seems as if we are penetrating ever more into the very realm of the gods.

Such questions as How large exactly is the Universe? Did it have a beginning? and if yes, Why? and How? are asked by people who look up at the stars and want to know what is behind them. Since the invention of the telescope in the early years of the 17th century, we think we have made good progress towards answering the first of these questions. We can study the Universe as it is today and develop reasonable ideas about its size and structure. It is more difficult to answer questions about past events (most likely a very remote past which no human being has witnessed), for such information can only be obtained through indirect methods.

This remoteness in space and in time, however, has not stopped man's investigation. From time immemorial there have been speculations, eventually followed by observations and calculations about the possible age of the Universe and the way it came into existence.

All measurement of time is based on the rate of changes. Ancient man saw the changing phases of the Moon; the Greeks observed the changing level of the water in their clepsydrae (water clocks); others noted the rising and setting of the Sun, or even much slower processes such as the growing of plants. From this last example it already becomes clear that slow changes are more difficult to measure than rapid ones, and that one must measure very carefully in order to cover the long time span over which the Universe has apparently existed.

Early ideas about this measurement of change are aptly expressed in the Bible, where scoffers are credited with saying that "Since the fathers fell asleep, all things continue as they were from the beginning of the creation" (2 Peter 3:4). Of course, this opinion also shows how difficult it is to measure slow changes. Little progress in determining the age of both the universe and this world was made in the centuries

following the above statement. A breakthrough came in the middle of the 18th century when Georges-Louis Leclerc, Comte de Buffon, used the idea that the Earth was originally molten and cooled to its present condition. In this way he estimated the age of the Earth to be a record-breaking 74,832 years!

Soon further steps were taken. In 1785 James Hutton formulated the main dictum of uniformitarianism: "The past history of our globe must be explained by what is seen to be happening today"; and in 1859 Charles Darwin published *The Origin of Species*. At first the ideas about long geological periods and slow biological evolution could not be supported by actual measurements of long periods of time, but this changed around the turn of the century. In 1896 Henri Becquerel discovered radioactivity, and 13 years later Lord Rutherford developed the technique of radio-dating. Chemical elements were seen to have a finite existence. Knowledge about the rate of their decay allowed a determination of their age. This impermanence raised questions among those who had always believed in the intransient character of the chemical elements, especially since the old claims of alchemy had been laid to rest.

A deeper question resulted from these developments. Because many chemical elements come to an end, do they also have a beginning? If so, when and where? The answer came from unexpected quarters. In the first half of the 20th century, astronomers discovered that the energy which stars radiate comes from nuclear processes deep in their interiors, and that these nuclear processes are able to build complex atoms from relatively simple ones. By the middle of the century this insight led to the astonishing idea that all chemical elements more massive than beryllium are formed inside stars.

2) THE STANDARD MODEL FOR THE ORIGIN AND DEVELOPMENT OF THE UNIVERSE

This insight did not answer all questions. Soon people were asking the old questions with renewed confidence that answers might be forthcoming: Where do stars come from? Did the Universe have a beginning? and if "yes," When? and How? One of the greatest developments in astronomy occurred in the second half of this century with the formulation of various cosmological theories that offered answers to all these questions. The theory that has attracted most supporters is the so-called "Hot Big Bang" model, a summary of which is found in Table 1.

TABLE 1. The Hot Big Bang (or Standard) Model

A Short Description

- The Universe is 10-20 thousand million years old;
- It started with rapid expansion (inflation) of super hot and dense "primordial matter" consisting of subatomic particles, such as quarks and anti-quarks;
- The subsequent phase of expansion caused a gradual cooling;
- As the temperature dropped, other particles were formed: electrons and positrons, protons and anti-protons, neutrons, and finally nuclei of hydrogen, deuterium, helium, lithium and beryllium (the primordial elements);
- During the first 300,000 years or so, matter and radiation were coupled (in thermal equilibrium);
- When the temperature reached the vicinity of 3000 K, the Universe became transparent, i.e., matter and radiation "decoupled";
- Finally, galaxies and stars were formed.

[Note: Peebles at al. (1991) and Peebles & Silk (1990) give more information on the Standard Model and its merits, respectively; an alternative view is presented by Arp et al. (1990), and an evaluation of various theories for the origin of the Universe's large-scale structure is given by Kashlinsky & Jones (1991).]

This model is also called the Standard Model mainly because it is more consistently supported by astronomical observations than any other. Among these observations, three are considered especially important:

a) almost all galaxies show a so-called redshift;
b) the existence of a general radiation with a temperature of about 3 K, the so-called microwave background radiation (MBR) (here, K stands for Kelvin, the absolute temperature scale on which 273 K = 0°C); and
c) the observed cosmic abundances of hydrogen, helium, lithium and beryllium.

The redshifts had been found at a time when cosmological ideas had not yet been developed to a very great extent and before the Standard Model was conceived. Probably because of this, there is a larger element of philosophy in the interpretation of red shifts than of any other observations.

During the 1980s the Standard Model lost some of its popularity, primarily because certain observations were casting doubt on two of its main pillars — the redshifts and the MBR. In the case of the redshift determinations, the disturbing elements are the apparently discordant redshifts of many galaxies and quasars as exposed, e.g., by Arp (1987 and references therein), and the possibilities for non-cosmological redshifts summarized, e.g., by Narlikar (1989). Redshift observations and some of the problems involved in their interpretation will be discussed in Section 4.

In the case of the MBR, after its discovery and early agreement with theoretical predictions, its acceptance declined as solid support for the Standard Model, because increasingly accurate measurements failed to detect the inhomogeneities that the Universe's large-scale structure suggested should be present (e.g., Schwarzschild 1990). However, hopes that all would be well with the Standard Model were boosted by the recent announcement of inhomogeneities in the MBR (this will be discussed in Section 7).

3) REDSHIFTS AND THEIR INTERPRETATION

The principle behind the redshifts is very simple. Any wave emitted by a source which is moving with respect to the observer will have a changed frequency when observed. This is called the Doppler effect. For relative motion which increases the distance between source and observer, the light received will have a longer wavelength, i.e., it will be more red than at the source. Conversely, the light from an approaching source will be more blue.

The question of whether galaxies were objects in our Milky Way or were other "milky ways" (galaxies) at large distances was the subject of a celebrated debate in 1921. The conclusions to be drawn from that debate were unclear, but the matter was settled in 1924 when Edwin Hubble studied Cepheid variable stars in other galaxies and proved unambiguously that the majority of observed "nebulae" (as all nebulous objects including the external galaxies had been called until that day) were indeed at great distances outside our Galaxy.

Hubble and others then proceeded to observe many galaxies and found that almost without exception they showed red-shifted spectral lines which seemed to resemble Doppler shifts, i.e., they seemed to be the result of receding movement. There are at least two serious objections against the way in which this interpretation was derived: 1) it includes a

number of philosophical assumptions which should not be present in a purely scientific process; and 2) while it assumes that the observed redshift is caused by the Doppler effect, one should not forget that there are other ways in which redshifts can be produced.

By the end of the 1920s, when Hubble had enough observations to begin formulating possible interpretations, he was already convinced of the large distances of the galaxies. What he saw amounted to increasing redshifts for galaxies at increasing distances from the Sun. Hubble, however, was careful not to call them Doppler shifts. He called them "apparent velocity-displacements," thus leaving open the way they should be reinterpreted.

Nevertheless, Hubble could not escape the challenge of interpreting his observations. To do this he needed a model of the Universe into which his observations could be fitted. There were three different cosmological models in those days, formulated by Georges Lemaître, Edward Milne, and Fritz Zwicky. Both Lemaître's and Milne's models were recessional, i.e., they included an expanding universe, in one form or other. Zwicky's model was non-recessional.

To distinguish between the recessional and non-recessional model, it is necessary to measure nebulae at very large distances where the difference between recession and no recession becomes increasingly apparent. Unfortunately, the faintness of the nebular images produced by the instruments of those days did not allow a reliable measurement of sufficiently distant nebulae.

In their analysis, Hubble and Tolman (1935) introduced a brightness correction Δm which allows comparison of nebulae at different distances. The correction increases with distance and is larger in a recessional model. Spatial curvature also affects the value of Δm, but only in recessional models. To fit their observations to the two models, Hubble and Tolman had to introduce a rather strong spatial curvature into the recessional model, and they concluded:

> *... it might be possible to explain the results on the basis of either a static homogeneous model with some unknown cause for the red-shift or an expanding homogeneous model with the introduction of effects from spatial curvature which seem unexpectedly large but may not be impossible.*

However, they also state that the necessity to introduce spatial curvature

> *... must be regarded as in conflict with our usual notions as to the distances to which observations would have to be*

carried before appreciable effects from spatial curvature would seem probable.

In other words, curvature effects are only noticeable at distances much larger than those of the farthest galaxies that had been observed until then.

Thus, the observational evidence pointed towards non-recessional models of the Universe. However, in subsequent papers, Hubble showed a clear inclination towards recessional models, and he finally concluded that the Universe must be expanding.

According to Hetherington (1971), Hubble arrived at this conclusion primarily because of deep philosophical reasons, for he assumed two very fundamental principles: General Relativity and the Cosmological Principle (discussed below). Because Zwicky's theory did not fit the prediction of an unstable universe made by the theory of General Relativity, and because it introduced so-called new physics to explain new observations, Hubble rejected it despite the indications to the contrary from his own observations. Thus, the cornerstone of one of the most interesting and important theories concerning the origin of everything was laid on a philosophical foundation. This often-forgotten fact is appropriate to recall here because scientists often accuse creationists of committing this kind of "mortal sin" in other areas.

The fact that the Standard Model has a philosophical foundation does not imply that it is necessarily flawed. However, in a society that aims at understanding the Universe in purely physical terms, the Standard Model should at least be viewed with a good dose of suspicion. In principle, other mechanisms can produce redshifts, and they have been evaluated by Narlikar (1989). Although some of these do not seem to harbor much promise, various possibilities remain open, encouraging the seeker for truth about the origin and structure of the Universe not to hesitate to investigate alternatives to the Standard Model.

4) THE COSMOLOGICAL PRINCIPLE

In speaking of the Universe we are really referring only to the Visible Universe. The actual Universe may be infinitely larger but, by definition, we cannot know anything of what happens beyond our cosmological horizon. The Cosmological Principle has been invoked to extend our knowledge of the Visible Universe to the Universe as a whole. In its simplest form it states that the Universe looks the same from every location within it.

At first it may seem that the increasingly large redshift of the more distant galaxies would lead to the inescapable conclusion that the Earth is the center of an expanding Universe, and therefore contradictory to the Cosmological Principle. However, this is not really a problem. An expanding universe in which the rate of expansion increases linearly with distance does look the same from every location within it. However, the Cosmological Principle is a purely philosophical assumption which is unfalsifiable because we are unable to move to a sufficiently different location in space to check its validity.

In fact, at whatever scale one looks, the Cosmological Principle does not seem to hold. The Solar System looks very different from different locations within it, and the Milky Way with its flattened disk and spiral arms does not look the same from every viewpoint. Looking at the galaxies in the Local Group, in the Local Supercluster, or at even larger distances, one sees very inhomogeneous distributions of matter. One can maintain that all this unevenness will smooth out if one were to look at larger scales. With our sophisticated astronomical instruments, we seem to be able to see almost as far as we possibly can (e.g., for a very large redshift of $z = 4$, we can see galaxies at a time when the Universe was only 20% of its present size). This means that we can investigate the Universe over a substantial fraction of the entire diameter of what could possibly be seen. The fact that we have seen structures on ever larger scales and not much of the smoothness postulated by the Cosmological Principle (Schwarzschild 1990), does not augur well for the ultimate triumph of the Cosmological Principle when extended to the whole Universe. Furthermore, if the Cosmological Principle does not hold, the Standard Model on which it is based is also in trouble. This is a second reason to consider alternatives to the Standard Model: the Cosmological Principle is not a very sound foundation on which to build, despite its philosophical attraction in some quarters.

Let us consider a biblical view of the Cosmological Principle, especially with respect to the Earth which has a special place in God's Word. Is Earth's special place contradictory to the Cosmological Principle? Probably not; Earth's unique role is related to its moral condition. Considered as a planet in the physical sense, Earth may not be unique, despite the definite impression we get that many of the heavenly bodies were created especially for the benefit of the Earth and its people (see Genesis 1:14-17, "lights" and "signs"). Astronomers have various arguments in favor of an abundance of planets throughout the galaxies (see,

e.g., Huang 1959), and even the Bible seems to imply that there are many other worlds — inhabited planets — in the Universe.* The problem for those who practice physical cosmology is twofold: 1) the apparently logical assumption of the Cosmological Principle is deeply philosophical, and 2) it may not even be true.

5) THE AGE OF THE UNIVERSE

Before discarding the Standard Model, we must consider another of its aspects. The possibility that the Universe is actually expanding is of interest to the creationist, as well as to others. If the Universe is expanding today, it must have been smaller in times past. Going back far enough in time, one arrives at an epoch when all things in the Universe were at their closest just before they were driven apart by the Big Bang. This would point to a definite beginning of time in the Universe, an idea very much in harmony with the way the Genesis record is often interpreted.

There are also troublesome aspects to the Big Bang hypothesis. For creationists the biggest problem is the long time that allegedly has elapsed since the explosion that set everything into motion. It is not immediately obvious that there is any possibility of reconciling the postulated 15 or so thousand million years since the Big Bang with 6000 or so years since the events reported in Genesis 1. The problem has some similarity to the time problem in geology. Radio-dating methods have given ages of millions or billions of years for many rocks; ages which, despite their being subject to the problems inherent in our lack of knowledge concerning initial clock settings, seem reliable but which cannot be reconciled with a 6000-year time scale and have forced consideration of an old age for planet Earth. I think that the Genesis record does not contradict such a conclusion (Roth 1992), and that despite problems concerning the initial setting of the radiometric clocks, it is quite acceptable to believe that many of the old radio-dating ages for terrestrial rocks indicate an ancient Earth.

An age of 15 thousand million years for the Universe would not disagree with the geological age of planet Earth, which is only a factor three smaller. However, there are other ways in astrophysics of estimating

*Texts such as Nehemiah 9:6, Job 1:6-7, Luke 3:38, and Ephesians 3:15 can be understood as pointing to "sons of God" who could, like Adam, have been the fathers of races on other worlds, but who all belong to the Universe-wide family of God.

age which give more doubtful conclusions, because conditions similar to initial clock settings are unknown. One is the assumption that in the initial stage of the Universe there were not only hydrogen, helium, lithium and beryllium as the Standard Model indicates, but that there were also heavier elements. Such an initial enrichment is not possible under Big Bang Model assumptions which limit the quantities of heavier elements produced in the very early stages to negligibly small amounts, and delay significant production to later inside stars (Wagoner, Fowler & Hoyle 1967). Astrophysical observations indicate quite unequivocally that, within the context of the Standard Model, there have been no primordial elements other than H, D, ^{3}He, ^{4}He, and ^{7}Li (Pagel 1991).

This does not necessarily prove that only these five primordial elements were produced in the hot Big Bang of the Standard Model. There are several mechanisms of baryosynthesis (Schramm 1991), even at temperatures as low as 10^{15} K (Linde 1991). (Compare this with the temperature of 10^{32} K supposed to have existed at the time of the Big Bang.) If any of these other mechanisms has been operative on a large scale, the abundance of the heavier elements at the time the first stars were formed could have been much higher than the Standard Model predicts, and problems similar to the clock setting in radio-dating methods arise. If this were the case, many age calculations done by the theory of stellar evolution would be invalid.

In conclusion, we find that both geology and cosmology use dating methods capable of giving reliable results (which are not contradictory to the Bible record even when they give extensive ages for certain objects), while there are other methods whose results must either be received with much caution or rejected altogether. Unfortunately, because we are dealing with events from the remote past, it is not always easy to decide which methods are the more reliable. Even when there are good arguments favoring an "old" Universe, its precise age remains difficult to determine, and there is room for considering alternative cosmologies.

6) THE ECHO OF THE BIG BANG

In the Big Bang scenario, the Universe started with an extremely high temperature and cooled as it expanded. After about 300,000 years, when the temperature had decreased to 3000 K, matter and radiation became decoupled, i.e., the density and temperature of the Universe had become so low that the two were no longer connected on an equilibrium

basis. Thereafter the Universe has expanded a thousandfold in every direction; stars, galaxies, planets and man have come into being; and the background temperature of the Universe has dropped to a mere 3 K.

This radiation is called the "echo of the Big Bang." Arno Penzias and Robert Wilson were awarded the Nobel Prize for its discovery in 1964. Also called the 3 K microwave background radiation (MBR), its detection was one of the main reasons why most scientists accepted the Standard Model as the true description of the Universe. However, in order for stars and galaxies to form subsequently, small density inhomogeneities from which later stars and galaxies could grow must already have existed at the moment of decoupling of matter and radiation. The corresponding fluctuations (anisotropy) in the MBR have been predicted by theory to be about one part in 10^5 over angular scales of 1^o to 90^o.

Until recently, all observations have found the MBR to be extremely isotropic, even from widely differing directions. For two reasons, this had always been considered a serious set-back for the Standard Model. First, regions of space so far apart that there could not have been a causal connection since the moment of the Big Bang still show the same temperature. This problem was solved by postulating a so-called "inflationary" phase during the very first moments after the Big Bang. This initial phase of comparatively rapid expansion led to a highly homogeneous, isotropic Universe, free from such complications as magnetic monopoles, primordial black holes and others (Guth 1981). Second, the presence of MBR isotropy cannot be reconciled with the existence of large-scale structure in the Universe, which can only be understood if there were density fluctuations in the early stages. These fluctuations would be seen today as in-homogeneities in the distribution of the MBR over the sky. The expected MBR in homogeneities were small and had not been detected despite a large number of thorough searches (Schwarzschild 1990).

For the survival of the Standard Model, a solution to this MBR problem was vital. A special satellite named COBE (Cosmic Background Explorer) was launched in 1990. COBE's first measurements showed the customary perfect black-body distribution of radiation with a temperature of 2.735 K, with deviations less than one quarter of 1%. More recently, however, with the accumulation of more data, it has become clear that the MBR is not completely uniform. The April 1992 announcement of the discovery of fluctuations in the MBR caused a flurry of publicity. There are temperature fluctuations with an amplitude

of 1.6×10^{-5} K, very close to the theoretical prediction (Goss Levi 1992). From this point of view the COBE measurements agree with the present-day large-scale structure of the Universe as predicted by the inflationary Standard Model. The recent measurements do not, however, point unequivocally to one particular cosmology (nor even to one particular group of cosmologies) as the only valid description of the Universe's origin and structure (Flam 1992).

There are still problems to be solved. On smaller scales, for instance, the Standard Model predicts too much gravitational influence (Silk 1992). Be this as it may, the detection of the MBR fluctuations is a remarkable achievement. The still-existing discrepancies between prediction and observation require a deeper understanding of the way galaxies and clusters are formed. The search for mechanisms and viable alternative hypotheses must continue before a final verdict can be given.

Many newspapers and other media reports asked the question: With this fresh confirmation of the Standard Model, does God still fit into the picture, and how? The COBE team leader George Smoot was quoted as saying, "If you're religious, it's like seeing God." It should be understood that these measurements are at the limit of detectability and need independent confirmation before they will be widely accepted. Furthermore, COBE was not designed to answer any religious questions. Nevertheless, these measurements provide another step in scientists' attempts to construct a "theory of everything." However, in its attempts to find explanations for everything, physical science finds itself limited to the physical world, and it will sooner or later have to admit that there are other than physical realities to the Universe. God is such a reality and, therefore, is not subject to physical investigation (though some of His actions may be), and neither is His existence in question here. Rather, the limitations of science will contribute to a confirmation of the claims made in His Word.

7) FINE-TUNING OF THE UNIVERSE

Another interesting characteristic of our Universe of which we have become aware from the claims of the Standard Model (and one which creationists have often been quick to point out and try to use to their advantage) is the fine tuning of physical parameters. Consider the initial force of the Big Bang. If this force were too large, the Universe would expand quickly to a state of low density in which there would be insufficient material to form stars and galaxies. On the other hand, if

the force of the initial explosion were too small, gravitational attraction would have slowed down the expansion long ago, and the Universe today would either be contracting or have collapsed. Neither possibility corresponds to the real Universe as we know it. This means that the force of the Big Bang had to be finely tuned.

In order to appreciate how finely tuned, we must realize that the final fate of the Universe as far as its expansion is concerned depends entirely on the density of the matter within it. The critical density which divides the two possibilities of eternal expansion and future contraction is about 5×10^{-30} g cm^{-3}, which corresponds to about 3 hydrogen atoms/m^3. A determination of the actual density of the Universe would allow a good guess about its future. Such an estimate is not easily made, and values given by different scientists obtained with different methods vary. Nevertheless, all such estimates show that the present density of the Universe is quite close to the critical value. This is a remarkable coincidence that has been difficult to explain. This so-called "flatness" problem is remarkable because a "flat" Universe today means its density must have been finely timed in its early phases (i.e., the tuning at a very early epoch must have been accurate to 1 part in 10^{49}). This is not fine tuning; this is *extremely* fine timing! If the original density had been slightly higher, the Universe would already have collapsed. Had it been slightly lower, today's density would not have been enough for stars and galaxies — and, as evolutionary proponents of the Standard Model say, for man — to form.

This near equality of the actual and the critical densities has inspired many cosmologists to believe that these two values are indeed identical, and that the Universe will continue to expand forever. One can easily understand how such an opinion comes to be expressed. The fact that we are here becomes a less probable situation only if the Universe has had sufficient time to develop us, i.e., if it is flat.

Although the assumption of a flat Universe has a strong philosophical bias, it has been possible to construct a theory which explains why this situation exists. The inflationary universe scenario introduced in 1981 by Guth (1981) and later modified by Linde (1983) solved the flatness problem by depicting a universe which is indistinguishable from a flat one, i.e., it predicts that the present density of the Universe is very close to its critical value. However, since inflation to the present status is possible only if a very special set of initial conditions is met, this scenario carries its own fine tuning (Narlikar 1988).

The above argument, and similar ones based on other instances of fine-tuning (see Section 9 and Gribbin & Rees 1990), can also be reversed. One could say that the Universe is as it is because we are here to observe it. This is one form of the so-called Anthropic Principle. For creationists this may seem to offer a fantastic opportunity to practice natural theology. One would first point out the near impossibility of this fine tuning and then proceed to argue that it could have been achieved only if there was a higher power responsible for it.

Those who would use this argument to favor creationism should consider that it is impossible to prove the existence of God through scientific arguments. As Barrow (1990, p 365) has stated, such arguments have to start with certain assumptions and then proceed by deduction to infer the existence of God. Such a process does not lead to firm inescapable conclusions, but rather to choices about believing or not believing the starting assumptions. The Anthropic Principle identifies certain necessary conditions for the existence of life, but these conditions do not guarantee that life will exist. Also, the fine balancing seemingly implied in the Standard Model could disappear if the Big Bang never happened, or if we arrive at a more complete understanding of its mechanism which explains how the coincidences occurred. Finally, we must grant science time to find its own tuning mechanism. While at this moment a direct action by the Creator may be invoked for an "explanation," one cannot be sure that this is the scientifically safe, long-term position. The absence of a tuning mechanism today cannot be construed to be evidence that such a mechanism does not exist. However, as Barrow (1990) concludes, while the Anthropic Principle cannot be used as a proof of God's existence, it certainly does not contradict such a conclusion.

8) MATTER/ANTIMATTER ASYMMETRY

Yet another example of fine timing is the relation between matter and antimatter in the early Universe. For almost every type of matter particle there is an antiparticle. Positrons are the antiparticles of electrons, protons go with antiprotons, etc. Bringing together a particle with its corresponding antiparticle results in the complete annihilation of the two particles, and the simultaneous production of electromagnetic radiation. Theoretically, matter and antimatter would have come into existence in equal amounts at the time of the Big Bang. Such a perfect symmetry would have resulted in the complete annihilation of both, and

the Universe today would have consisted of radiation only. This is clearly not the case; the Earth below our feet is real matter!

Somehow, the Big Bang produced more matter than antimatter. After all antimatter was annihilated by matter, the particles which make up today's Universe remained. The energy content of the Universe today is the remnant of this annihilation radiation. Since matter carries only one part in 10^9 of the Universe's energy and the rest is in radiation, this means that for every 10^9 antiparticles, 10^9 and one particles were formed. According to the Big Bang theory, this is why matter, including ourselves, exists.

Recently, some progress has been made towards explaining this asymmetry. It depends on two different mechanisms: a) a process of converting matter into antimatter and vice-versa, also known as baryon-number-conservation violation; and b) some asymmetry between matter and antimatter that would make the above process favor the direction towards matter, also known as charge-parity symmetry violation. The first process could possibly be found in an amplified version of the 't Hooft effect ('t Hooft 1976a,b; Shaposhnikov 1991). The second requirement has been harder to meet. Recent speculative extrapolations (McLerran et al. 1991), while offering some promise of success, need the Super-conducting Super Collider to confirm that speculations are on the right track (Freedman 1991).

Even if such experimental support should be forthcoming, there will still be a problem in validating the proposed mechanisms, because they are effective only at energies well beyond what our highest hopes for particle accelerators can reasonably expect. Also, they were operative in an era far earlier than the production of the light that can be detected by any telescope.

We see, again, that in order to explain certain aspects of the Universe, science must have recourse to unverifiable theories. In matter/antimatter considerations there is additional evidence that science leaves plenty of room for believing in the miraculous (i.e., not according to known natural laws) intervention of God in the origin of the Universe.

9) HOW THE UNIVERSE BEGAN

While there seems to have been some success in answering the question about when the Universe began, science has found it much more difficult to answer the question about *how* it began. Several recent ideas about its beginning have been proposed. Rather than crediting

God with an act of creation, physicists have conceived "natural" processes which might produce a universe like ours. We are almost capable of reproducing the conditions necessary for one such process (quantum mechanics) to occur in the laboratory, using a total mass of only about 10 kg (Guth 1991 and references therein).

Another proposal lies in so-called quantum fluctuations in which particles emerge spontaneously and temporarily from a vacuum (Tryon 1983). There is an uncertainty relation for the particles' net energy, E, and their lifetime, t, with $\Delta E \times \Delta t \sim h$. A vacuum fluctuation on the scale of the Universe may be possible because theory does not limit the scale as long as this uncertainty relation is fulfilled. Accordingly, such a Universe can exist sufficiently long, $\geq 15 \times 10^9$ years, if the energy is sufficiently small. This is believed possible in a closed universe in which physical quantities are conserved, and particles and their antiparticles are generated in equal amounts, so that the total net energy of the Universe, the sum of mass energy and potential energy, is zero or almost zero.

This is one example of how modern theoretical physics attempts to find answers to the question of what the Universe really is, and how it was formed. One might ask whether the veil on creation has now been lifted and science has found the secret. Before an affirmative answer is given, it should be remembered that we are dealing with phenomena at the very edge of (and beyond) our knowledge of physical theory, and that, therefore, the uncertainties about the validity of the assumptions are at least as large as in the case of creation of all matter by God in an even more miraculous way, i.e., outside the known laws of physics. Even if some of the proposed mechanisms are capable of some degree of verification through their predictions about present conditions, it will most likely still be impossible to give definitive, unambiguous answers to the question about how the Universe began.

Premonitions about this impossibility are probably among the main reasons why some scientists have tried to avoid giving any answer to the above question. Instead, they have postulated that the expansion of the Universe will ultimately cease and that thereafter there will be collapse. After it has collapsed to sufficiently high temperatures and pressures, conditions would be ideal for a new explosion or a bounce. This process might have been repeated many times. Such an "oscillating universe" could have existed from much earlier times, and continue to exist for a much longer time than a universe which continues to expand forever.

While experience suggests that entropy can only increase and that with each succeeding generation an oscillating universe would slowly degrade, it is also conceivable that in the new physics entropy is largely or completely eliminated after a bounce. If in addition some fresh matter could be created in such a universe with every bounce (possibly through vacuum fluctuations), the universe would continually grow and contain enough particles to support life. Further, because of the increased energy content in every new cycle, each cycle would last longer than the previous one (Dicke & Peebles 1979).

Whatever the length of time a hypothetical universe can exist, the oscillating universe is an unsatisfactory answer to the question about origin. It is not (yet?) scientific because it postulates unverifiable conditions. And for the creationist it is no answer at all. While God's creation could have existed over a vast length of time, to have it go through a series of creation-like events and subsequent apocalyptic destructions seems contrary to all we seem to know about the Creator, despite the "precedent" of the worldwide Noachian flood. There is no need for a long history of the Universe, or the presence of a sufficiently high number of particles in order to facilitate the process of biological evolution, if one believes in the origin of all living things according to the Genesis account.

10) THE SINGULARITY

There are other philosophical reasons for considering alternatives to the Standard Model. Consider the physical conditions in the Universe at the time of the Big Bang. At that time many physical quantities had unrealistic values that modern physics has not yet been able to deal with and probably never will. In mathematics (the language in which scientists describe their models) this is called a singularity. Because physics cannot really deal with singularities, it looks as if there was something similar to ex. nihilo creation "in the beginning." If everything must have a cause, this is an argument for the existence of God as the One providing not only a physical cause but also deep philosophical and/or religious meaning.

On the other hand, if God Himself had no cause because He exists from eternity, one might ask why the Universe should have a cause. Why could it not have existed from eternity? In a world view which accepts the existence of an eternal God, this is equivalent to making the Universe sufficiently equal with God to produce a direct conflict with the Bible's presentation of God as the unique Creator.

Finally, it is also possible that the singularity does not exist at all in the real Universe but was introduced because of the shortcomings of our physical knowledge and mathematical tools. While it is an accepted and acceptable practice to describe nature by models that we know are only approximations to reality — often very close approximations indeed! — to reason about the origin of the Universe and the need for God from such approximate models seems to betray a deep reluctance to admit His existence and influence in the affairs of man, even a deliberate attempt to expel Him from His own world.

It is interesting to reflect for a moment on the implications of a possible singularity or a beginning of the Universe, by considering the following three necessary but insufficient conditions for the existence of such a singularity (Penrose & Hawking, as quoted in Barrow 1990, p 228):

a. Gravity must attract everything. This is a problem for the Standard Model because inflation requires just the opposite.
b. Time travel must be impossible. The Theory of Relativity, which forms one of the cornerstones of the expanding-universe model, allows time travel. In places where space is very strongly curved, it is theoretically possible to take a short-cut and reach a location in space-time which lies actually in the past. This, of course, causes a dilemma if the time traveler should find himself a contemporary of his grandmother and killed her before his mother (or father) was born. However, if the time loops are sufficiently large (i.e., if they carry us to a sufficiently distant past), the "what if I killed my granny?" contradiction could not yet have arisen.
c. The Universe is expanding and contains a sufficient quantity of matter for its ultimate collapse. It appears unlikely that this condition is fulfilled. There does not seem to be enough matter in the Universe for assurance that expansion will not continue forever.

These conditions cannot be fulfilled in the Standard Model. This does not mean that there has not been a singularity. The Universe could have had a beginning in time under different conditions. Whatever the difficulties, the search for physical processes must continue. It is to be expected that this search will, at best, lead to an indication of which processes were involved in the formation of the Universe, without being

able to provide us with real causes. I consider it highly probable that a set of alternative conditions could be provided by the action of God as Creator.

Thus, either the Universe had a beginning in space and in time, in a singularity or otherwise, or it existed from eternity. In either case it would be impossible to speak of "before." Here it is appropriate to recall the words spoken by Judge William Overton at the 1981/82 Arkansas Creation Trial:

> *'Creation out of nothing' is a concept unique to Western religions. In traditional Western religious thought, the concept of a creator of the world 'out of nothing' is the ultimate religious statement because God is the only actor.... The only one who has this power is God.... The idea of sudden creation from nothing, or creatio ex nihilo, is an inherently religious concept.*

It seems that scientific cosmologists are approaching religious thinking when they speak about virtual quantum fluctuations, charge-parity symmetry violation, and even singularities, as a way of starting the Universe! So why not admit that God is the Creator? After that we can use the Bible to find out why He created, and science to reveal some of His methods.

11) THE HUMAN FACTOR

Another philosophical reason for considering alternatives to the Standard Model lies in the so-called "human factor." Whereas only the very lightest chemical elements were produced in the first few minutes of the Big Bang, men and animals contain a large proportion of heavier elements. According to the Standard Model, these were generated in the nuclear ovens deep inside stars. Toward the final phases of a star's existence as a luminous body, when its central temperature is increasing to ever higher values, the processes of nucleogenesis generate the heavier elements. After the star's final breakup, these are delivered to interstellar space, ready for incorporation into the next generation of stars and planets. Somehow, somewhere, the conditions for the synthesis of complex molecules, such as amino acids, and other essential elements of life, would have been fulfilled to begin the long journey of evolution leading ultimately to man.

While this scenario has claimed to offer some harmony with the biblical statement about our formation from the "dust of the ground," it

does not explain how we came to possess the "image of God," and it reduces the Genesis account to mere mythology.

The Standard Model sees man as a unique product of physical, chemical, biological and other physical processes. In addition to explaining why the Universe and we are here, such human characteristics as love, hate, beauty, sorrow, happiness, etc., need to be addressed. The Standard Model offers only some explanation of how we came to be here — through the extremely improbable and therefore rather accidental synthesis of a number of amino acids. Those who want an answer to the deeper question of why we are here would be much better advised to consult the Word of God than the latest embellishments of the Big Bang theory. It is fair to say that here is a prime example of how the neglect of non-science by scientists has impoverished cosmology, resulting in a lack of direction, and much senselessness and fatalism.

The emptiness of today's model of the beginning of the Universe has been described clearly by Steven Weinberg (1978), who was awarded the 1979 Nobel Prize in physics:

> *It is almost irresistible for humans to believe that we have some special relation to the universe, that human life is not just a more-or-less farcical outcome of a chain of accidents reaching back to the first three minutes [of the universe], but that we were somehow built in from the beginning.... It is very hard to realize that this all is just a tiny part of an overwhelmingly hostile universe. It is even harder to realize that this present universe has evolved from an unspeakably unfamiliar early condition, and faces a future extinction of endless cold or intolerable heat. The more the universe seems comprehensible, the more it also seems pointless.*
>
> *But if there is no solace in the fruits of our research, there is at least some consolation in the research itself.... The effort to understand the universe is one of the very few things that lifts human life a little above the level of farce, and gives it some of the grace of tragedy* (p 154-155).

Another reason for considering alternatives to the Standard Model lies in the fact that its adherents reject various possible alternatives because they might be philosophically unattractive or unsatisfactory. Hubble's conclusion about the redshifts and the expanding Universe is an example. Scientists *do* have their own philosophical presuppositions. One would be their belief that everything must be explained through natural laws, maybe even typically non-physical phenomena such as

love, hate, beauty, and life. In this process there is no longer a need to include God. As Dyson once said, cosmology has deteriorated to the level of "cosmolatry."

12) THE DIVINE ALTERNATIVE

NASA astronomer Robert Jastrow (1978), after discussing the as-yet-inconclusive results of our investigations into the origin of the Universe, writes:

> *Now we would like to pursue that inquiry farther back in time, but the barrier to further progress seems insurmountable. It is not a matter of another year, another decade of work, another measurement, or another theory; at this moment it seems as though science will never be able to raise the curtain on the mystery of creation. For the scientist who has lived by his faith in the power of reason, the story ends like a bad dream. He has scaled the mountains of ignorance; he is about to conquer the highest peak; as he pulls himself over the final rock, he is greeted by a band of theologians who have been sitting there for centuries* (p 115-116).

I would like to think that the theologians of the above quotation have been enjoying the panorama their high position affords. Their presence reminds us of the possibility for considering alternative scenarios that go beyond the purely physical into the metaphysical and/or religious fields. We are even more justified in doing so because our discussion of the Standard Model has revealed numerous reasons why the search for alternatives must continue. There are the instances of fine-tuning which become all the more remarkable once one admits that the *a posteriori* explanation given through the Anthropic Principle may be an act of evading the real issue: To what extent must God be brought into the scenario to make it viable?

The role God would have played in the origin of the Universe varies with different people. Some say that because they don't know about the very beginning of things, nor about what went before or how life itself originated, we should believe in a God. This is the position of deistic evolution, which I consider a negative view. As soon as science finds an explanation for what is still a puzzle today, such a God is no longer required. This is one reason why even in many so-called Christian churches today, God has slowly but surely been pushed back further into the shadows.

A more positive view is to believe in creation by God as it is described in the Bible. People who believe in God on this basis never do so because of any shortcomings in scientific theories, but because they have a personal relationship with God which has taught them that His Word is thoroughly reliable. This view is also positive because it includes some understanding of good and evil, the purpose of life, and other non-physical questions which science cannot address. People with this view, realizing that there is more to the Universe than meets the eye, are open to some so-called unscientific alternatives which have already been rejected by the "pure" scientists. As Einstein once expressed it: "Science without religion is lame, religion without science is blind" (Frank 1947). God is not seen to be in competition with science as a means for explaining life and the Universe.

Finally, let us reflect on time before the singularity. In our physical theories there is no "before," i.e., the Universe must have originated spontaneously. The Bible tells us that before the "beginning" there was God. This has led some to ask what it was that God was doing before He created the Universe. The 5th-century sage St. Augustine of Hippo is said to have given this answer: "Before He created Heaven and Earth, God created hell to be used for people such as you who ask this kind of question" (Oliver 1988).

CONCLUSIONS

We can now give an answer to the questions posed at the beginning of this article. The current scientific picture of the origin and structure of the Universe — the Standard Hot Big Bang Model — is not altogether in conflict with the Genesis account. Those who acknowledge the lack of scientific definition in Genesis will find much room to accommodate many aspects of the Standard Model. Its great age of 15 billion years could be loosely correct if one limits this age to the inanimate, physical Universe. Those who are prepared to accept an extensive age for the physical Universe should acknowledge the considerable uncertainty regarding the exact value.

The Standard Model has weaknesses. First, the interpretation of the observed redshifts as due to a general expansion of the Universe is based on philosophical arguments, and goes beyond the normal confines of physical science. Second, another cornerstone of the Standard Model, the Cosmological Principle, is a purely philosophical assumption which

may be incorrect. Third, while the recent discovery of anisotropy in the MBR seems to provide solid support for the Standard Model (by being consistent with the formation of the present-day large-scale structure), some speculative physics is required over the very early inflationary phase to avoid producing a Universe without such anisotropies.

While the above are somewhat negative arguments for considering alternatives to the Standard Model, there are a number of remarkable coincidences in the Universe which point to an intelligent design. Among these we count the flatness (see Section 7) of the Universe. The fine tuning this requires has been accounted for in an early inflationary phase. However, the inflationary model needs some finely tuned physical conditions for its own success. This problem is not solved by the adoption of the Anthropic Principle (see Section 7). This is another instance of the introduction of deeply philosophical arguments into what is meant to be a purely physical theory.

Another coincidence is found in the small asymmetry between matter and antimatter. While science does not lack theories to explain this, these explanations are based on almost unverifiable assumptions, because the presumed physical conditions at the beginning of the Universe are so remote from what we will be able to simulate in our laboratories for many years to come. These limitations prevent us from penetrating the earliest moments of the Universe and theorizing successfully about how it actually came into existence. The possible occurrence of a singularity at the beginning of the Universe leaves room for considering non-physical alternatives.

The Standard Model unquestionably conflicts with Genesis on the origin, characteristics, and purpose of life. The Standard Model provides presumably sufficient time for biological evolution to take its assumed course, while Genesis states quite categorically that all life is created by God. In fact, since creation by God seems to be an activity not limited to one week of intense activity, but a process which is repeated at various times and places throughout the Universe, alternative cosmologies such as the modified steady-state theory proposed by Arp et al. (1990) would seem to agree much better with the Genesis record — if they did not depend so much on Hutton's principle of uniformity.

In the end we come back to God as the only One who can answer our questions, because He is the Creator of everything and gave it beauty and purpose so that we might enjoy it, and enjoy seeking answers to all our questions.

REFERENCES

Arp H. 1987. Quasars, redshifts and controversies. Berkeley, CA: Interstellar Media.

Arp HC, Burbidge G, Hoyle F, Narlikar JV, Wickramasinghe NC. 1990. The extragalactic Universe: an alternative view. Nature 346:807-812.

Barrow JD. 1990. The world within the world. NY: Oxford University Press.

Brown RH. 1990. Correlation of C-14 age with the biblical time scale. Origins 17:56-65.

Dicke RH, Peebles PJE. 1979. The Big Bang cosmology — enigmas and nostrums. In: Hawking SW, Israel W, editors. General Relativity. Cambridge: Cambridge University Press, p 504-517.

Flam F. 1992. COBE sows cosmological confusion. Science 257:28-30.

Frank P. 1947. Einstein: his life and times. NY: Alfred A. Knopf.

Freedman DH. 1991. Concocting a cosmic recipe for matter. Science 254:382-383.

Goss Levi B. 1992. COBE measures anisotropy in cosmic microwave background radiation. Physics Today 45(6):17-20.

Gribbin J, Rees M. 1990. Cosmic coincidences. New Scientist 125(13 January):51-54.

Guth AH. 1981. The inflationary universe: a possible solution to the horizon and flatness problems. Physical Review D 32:347-356.

Guth AH. 1991. Can a man-made universe be created by quantum tunneling without an initial singularity? Physica Scripta T36:237-246.

Hetherington NS. 1971. Edwin Hubble and a relativistic, expanding model of the universe. Astronomical Society of the Pacific, Leaflet 509.

't Hooft G. 1976a. Symmetry breaking through Bell-Jackiw anomalies. Physical Review Letters 37:8-11.

't Hooft, G. 1976b. Computation of the quantum effects due to a four-dimensional pseudo-particle. Physical Review 14:3432-3450.

Huang S-S. 1959. The problem of life in the universe and the mode of star formation. Publications of the Astronomical Society of the Pacific 71:421-424.

Hubble E, Tolman RC. 1935. Two methods of investigating the nature of the nebular redshifts. Astrophysical Journal 82:302-337.

Jastrow R. 1978. God and the astronomers. NY and London: W. W. Norton & Co.

Kashlinsky A, Jones BTJ. 1991. Large-scale structure in the Universe. Nature 349:753-760.

Linde AD. 1983. Chaotic inflation. Physics Letters B 129:177-181.

Linde A. 1991. Inflation and quantum cosmology. Physica Scripta T36:30-54.

McLerran L, Shaposhnikov ME, Turok N, Voloshin M. 1991. Why the baryon asymmetry of the universe is $\sim 10^{-10}$. Physics Letters B 256:451-456.

Narlikar JV. 1988. The primeval universe. NY: Oxford University Press.

Narlikar JV. 1989. Noncosmological redshifts. Space Science Reviews 50:523-614.

Oliver JM. 1988. Antes del Big Bang. Astrum (Magazine of the Agrupacion Astronomica de Sabadell, Spain) 81:3.

Pagel BEJ. 1991. Big-Bang nucleosynthesis — observational aspects. Physica Scripta T36:7-15.

Peebles PJE, Schramm DN, Turner EL, Kron RG. 1991. The case for the relativistic hot Big Bang cosmology. Nature 352:769-776.

Peebles PJE, Silk J. 1990. A cosmic book of phenomena. Nature 346:233-239.

Roth AA. 1992. “The fourth day: a discussion of some questions about the Genesis creation events.” Unpublished manuscript available through the Geoscience Research Institute.

Schramm DN. 1991. Big Bang nucleosynthesis: the standard model and alternatives. Physica Scripta T36:22-29.

Schwarzschild B. 1990. Gigantic structures challenge standard view of cosmic evolution. Physics Today 43(6):20-23.

Shaposhnikov ME. 1991. CP-violation and electroweak baryogenesis. Physica Scripta T36:183-193.

Silk J. 1992. Cosmology back to the beginning. Nature 356:741-742.

Tryon EP. 1973. Is the universe a vacuum fluctuation? Nature 246:396-397.

Wagoner RV, Fowler WA, Hoyle F. 1967. On the synthesis of elements at very high temperatures. Astrophysical Journal 148:3-49.

Weinberg S. 1978. The first three minutes: a modern view of the origin of the universe. Rev. ed. NY: Basic Books, Harper-Collins.

ANNOTATIONS FROM THE LITERATURE

GENETICS AND EVOLUTION: ANTI-MUTATION MECHANISM

Gimble FS, Thorner J. 1992. Homing of a DNA endonuclease gene by meiotic gene conversion in *Saccharomyces cerevisiae*. Nature 357:301-306.

Summary. The yeast *Saccharomyces* contains a gene that produces a subunit of a vacuolar membrane enzyme. The enzyme (VMA1) is produced from a larger protein by removal of a smaller protein. This paper reports that the smaller protein is actually an endonuclease. This endonuclease has the ability to attack any copy of the VMA1 gene that does not include the sequence for the endonuclease. If only one copy of the VMA1 gene lacks the sequence for the endonuclease, the endonuclease produced by the other copy of the gene will attack the defective gene. The gene will be cut at the exact spot where the endonuclease sequence should be, and the missing sequence will be copied into the defective gene. This type of mechanism for correcting genetic errors has previously been found only in introns.

GEOLOGY: "PSEUDO-PALEOSOLS"?

Rossinsky V, Wanless HR, Swart PK. 1992. Penetrative calcretes and their stratigraphic implications. Geology 20:331-334.

Summary. Calcrete (caliche) horizons have been commonly used to identify subaerial exposures. Recent work by Rossinsky et al. has identified a series of multiple calcrete horizons extending as deep as 5 m that they term "false penetrative calcretes." The entire system of penetrative calcretes is indicative of a single subaerial exposure. The penetrative calcrete horizons occur along subhorizontal surfaces (sequence or lithologic boundaries) and are connected by vertical rhizoliths (calcrete or chert having a root-like form). Use of the calcrete layers as indicators of distinct subaerial events from core borings may result in an incorrect calculation of the number of lowstand events in a marine deposit. Previous work indicated that the calcrete horizons may be joined by a single taproot. In addition, calcretes formed subsurface are more likely to be preserved than those formed subaerially.

Both papers cited fluctuations in the water table as a significant factor in calcrete horizon formation.

GEOLOGY: RADIOMETRIC AGE CONTAMINATION?

Seaman SJ, Ramsey PC. 1992. Effects of magma mingling in the granites of Mount Desert Island, Maine. Journal of Geology 100:395-409.

Summary. Fine-grained inclusions (enclaves) in felsic plutons and volcanic rocks are usually interpreted as magmas that cooled and crystallized when they came into contact with their more siliceous host magmas. The minerals that crystallize from the enclave liquids and disaggregate into the host granite contaminate the granite with exotic components. Three mechanisms affecting composition and texture of the granite are described: 1) disaggregation and dispersion of crystals from pegmatite pods formed during the cooling of the enclave liquids, 2) ionic exchange between the enclave and granitic magmas, and 3) alkalic feldspar and hornblende rinds surrounding the enclaves. While the third process of rind development simplifies the process of identifying the extent of contamination in granites, the authors state "... textural and compositional data presented in this study suggest that the effects of ionic and mineralogic contamination by enclave liquids may be strong and pervasive, regardless of the appearance of a granite."

MOLECULAR PHYLOGENY

Hillis DM, Dixon MT. 1991. Ribosomal DNA: Molecular evolution and phylogenetic inference. Quarterly Review of Biology 66:411-453.

Summary. This article reviews the results of analysis of DNA sequences for ribosomal RNA (rRNA). A 7-page appendix references a large number of phylogenetic studies using ribosomal DNA sequences. Ribosomal RNA participates in the structure of the ribosomes, where proteins are made. Three or four main segments rRNA genes are present in the nuclei of most cells. The largest of these is a large subunit RNA (called 28S) of over 4000 nucleotides in length. This is associated with a smaller sequence (5.8S) of about 160 nucleotides. The rRNA (16S) making up the small subunit of the ribosome has about 1500 nucleotides. A fourth sequence (5S) of about 120 nucleotides is present in eukaryotic cells. Ribosomal DNA (rDNA) sequences are also present in mitochondria and chloroplasts. The DNA sequence of

the large subunit rDNA varies among species much more than do the two smaller sequences. The authors state that sequences should be at least 70% similar to be useful in phylogenetic studies, a condition that rDNA seems to fulfill better than many other molecules. One problem with rDNA studies is that multiple copies of the genes seem to maintain greater homogeneity among themselves than would be expected if each copy were evolving independently. This phenomenon, known as "concerted evolution," is commonly seen in gene families having multiple copies, and confounds to some degree the process of phylogenetic interpretation.

Furhman JA, McCallum K, Davis AA. 1992. Novel major archaebacterial group from marine plankton. Nature 356:148-149.

Summary. Marine bacteria are not well known because of difficulty in culturing them for identification. Molecular comparisons can be made without the need for culturing. No archaebacteria, but only eubacteria, have been found in samples from the ocean surfaces. The authors analyzed 16S rRNA sequences from bacteria taken from below the ocean surface. These new sequences differ from those of any known bacteria as much as plants and animal sequences differ from each other. These bacteria may represent a new group not similar to any known group of organisms.

Cunningham CW, Blackstone NW, Buss LW. 1992. Evolution of king crabs from hermit crab ancestors. Nature 355:539-542.

Summary. King crabs are among the largest arthropods living. Like hermit crabs and several other groups, they have asymmetrical abdomens. Fossil hermit crabs are known at least from the Cretaceous, but no fossils of king crabs have been found. This paper reports on a molecular comparison of the gene for a mitochondrial ribosomal RNA molecule of hermit crabs and king crabs. Results showed that the king crab molecular sequence was more similar to that of some species of hermit crabs than were some sequence comparisons among hermit crab species from the same genus (*Pagurus*). The authors suggest that king crabs might be derived from hermit crabs that outgrew their ability to fit into discarded molluscan shells.

Joss JM, Cramp N, Baverstock PR, Johnson AM. 1991. A phylogenetic comparison of 18S ribosomal RNA sequences of lungfish with those of other chordates. Australian Journal of Zoology 39:509-518.

Summary. The origin of the tetrapods is generally traced to one or two groups of fishes. Most morphologists have favored the extinct rhipidistians as closest to the ancestry of tetrapods, while others have favored the lungfish. Because it is generally believed to be descended from the extinct rhipidistians, the coelacanth should therefore be more similar to tetrapods than is the lungfish. In this study, ribosomal RNA gene sequences were compared for five groups of fish and two groups of amphibians. A partial sequence of coelacanth rRNA was also compared. Lungfish did not group well with any of the other groups included in the study. This leaves the relationships of tetrapods, coelacanths and lungfish unresolved, despite many years of intense study and debate.

Westerman M. 1991. Phylogenetic relationships of the marsupial mole, *Notoryctes typhlops* (Marsupialia: Notoryctidae). Australian Journal of Zoology 39:529-537.

Summary. The marsupial mole is found only in Australia, where it burrows in sandy soils in the interior of the continent. Its relationships to other marsupials have been enigmatic, and it has generally been placed in a group by itself, sometimes in a separate Order. Fossil moles have been nearly unknown, but some fossils have recently been discovered at Riversleigh, Queensland. These fossils are similar in structure to the living moles, giving no hint of relationship to any other marsupial group. This paper reports the results of DNA-DNA hybridization studies comparing the marsupial mole to various other groups of marsupials. The DNA results are similar to other kinds of data in indicating that the marsupial mole is not similar to any other group of marsupials, but should be maintained in a group by itself.

PALEOECOLOGY: ECOLOGICAL ZONATION?

DiMichele WA, Aronson RB. 1992. The Pennsylvanian-Permian vegetational transition: A terrestrial analogue to the onshore-offshore hypothesis. Evolution 46:807-824.

Summary. The authors note that floras from Lower and Middle Pennsylvanian deposits are typically wetland types. Upper Pennsylvanian floras include both wetland and drier types. Drier habitats

predominate in Permian deposits. Several prominent Upper Permian and Mesozoic taxonomic groups have first appearances in drier type floras. The authors compare this ecological trend with the onshore-offshore hypothesis of ecological trend in terrestrial deposits.

Comment. Such examples indicate ecological trends in depositional sequences that might profitably be examined in the context of ecological zonation theory.

PALEONTOLOGY

Han T-M, Runnegar B. 1992. Megascopic eukaryotic algae from the 2.1-billion-year-old Negaunee Iron-Formation, Michigan. Science 257:232-235.

Summary. Fossils believed to be those of a macroscopic alga have been discovered in Precambrian deposits in Michigan. The fossils are about 1 mm in diameter and up to 90 mm in length. If correctly identified as eukaryotes, these are the stratigraphically lowest eukaryote fossils yet found. The inferred photosynthetic ability of these fossil algae requires a very early date for the widely accepted hypothesis of an endosymbiontic origin of chloroplasts.

Briggs DEG, Fortey RA, Wills MA. 1992. Morphological disparity in the Cambrian. Science 256:1670-1673.

Summary. In his book *Wonderful Life*, Stephen Jay Gould states that the fossils of the Burgess Shale show an extraordinarily great diversity of body plans. Gould uses the term "disparity" to distinguish the idea from large numbers of species. Briggs et al. take exception to Gould's characterization of great disparity within the Burgess Shale arthropods. Briggs et al. used principal components analysis to compare the disparity among living and Burgess Shale arthropods. They concluded that living arthropods exhibit essentially the same degree of disparity as Burgess Shale arthropods.

Comment. It is, nevertheless, remarkable that the diversity of body plans found in a single fossil locality, and a Cambrian locality at that, would be as great as found among all living arthropods worldwide.

Sansom IJ, Smith MP, Armstrong HA, Smith MM. 1992. Presence of the earliest vertebrate hard tissues in conodonts. Science 256:1308-1311.

Summary. Conodont fossils are widely distributed both geographically and stratigraphically, mostly in Paleozoic deposits, including

the Cambrian. For many years no one knew what kind of animal produced the tooth-like conodont fossils. Recent discoveries have shown that the tooth-like fossils functioned as teeth in the mouths of the small, soft-bodied swimming conodont animals. This paper reports on the presence of cellular bone in conodont elements, leading to the conclusion that conodonts must be considered to be vertebrates.

Comment. Enamel-like tissues are found, but no dentine, contrary to the evolutionary hypothesis that dentine is primitive with respect to enamel.

Sereno PC, Chenggang R. 1992. Early evolution of avian flight and perching: New evidence from the Lower Cretaceous of China. Science 255:845-848.

Summary. A newly described fossil bird from China is said to be an important link between *Archaeopteryx* and modern birds. The sparrow-sized bird was discovered in Lower Cretaceous lake deposits in northeastern China.

The new bird, named *Sinornis santensis*, shares several reptilian traits with *Archaeopteryx*. The snout is short and toothed. The carpus and manus are separate. The metacarpals are separate and with digits. The pelvic girdle elements are free rather than co-ossified. The iliac blades are erect; the ischiurn is blade-shaped; and the pubis seems directed ventrally, terminating in a hook-shaped foot as in *Archaeopteryx*. The metatarsals are fused only at the proximal ends. Gastral ribs are present, as are several advanced avian traits. The tail is short, and a pygostyle is present. The shoulder joint permits raising of the wing above the level of the vertebral column. The second digit of the manus and the ulna support flight feathers. The wing seems to have been capable of folding. The manus is shorter than the forearm or the humerus. The hallux (thumb) is opposable, and the fifth digit of the pes is absent. The authors reject the proposed avian character of the upper Triassic *Protoavis*. *Sinornis* shows supposed advances over *Archaeopteryx* for flight, but retains several ancestral traits.

Lockley MG, Yang SY, Matsukawa M, Fleming F, Lim SK. 1992. The track record of Mesozoic birds: evidence and implications. Philosophical Transactions of the Royal Society of London, Series B 336:113-134.

Summary. Bird footprints are more common in Mesozoic sediments than is generally recognized. Several factors may have contributed to a general failure to recognize bird tracks. The paucity of fossil birds in

pre-Cretaceous deposits may have hindered the recognition of pre-Cretaceous bird tracks. Dinosaur footprints are more common than bird footprints, which may have led to misidentification of some bird tracks as dinosaur tracks. Also, many Mesozoic bird tracks are found associated with larger and more spectacular dinosaur tracks, possibly resulting in the bird tracks being largely ignored.

Several criteria are presented for distinguishing bird tracks from other types such as dinosaur tracks. Several examples of tracks that meet the criteria for bird tracks are described. Most of the bird tracks appear to be those of shorebirds, and are especially similar to those of plovers. A few tracks are as large as those of large herons. Bird tracks have been discovered from the Lower Cretaceous of East Asia and North America, and from the Jurassic of Africa and North America.

Comment. The presence of numerous examples of shorebird tracks in deposits stratigraphically lower than *Archaeopteryx* is further evidence that *Archaeopteryx* is not the ancestor of birds.

Godthelp H, Archer M, Cifelli R, Hand SJ, Gilkeson CF. 1992. Earliest known Australian Tertiary fauna. Nature 356:514-516.

Summary. Several new fossil mammals and other vertebrates have been discovered in an Eocene clay deposit in Queensland, Australia. The fossils include turtles, crocodiles, snakes, frogs, birds and mammals. Most of the fossil mammals appear to be marsupials, none of which seem clearly related to any other known marsupials. A fossil bat is present, which is stratigraphically the oldest bat known. The most significant mammal fossil found in this deposit is a single tooth that is believed to be from a condylarth, an extinct group of placental mammals. Except for bats and rodents, this is the first fossil of a terrestrial fossil placental mammal to be discovered in Australia. Rodents have not been found in layers below the Pliocene. This adds a new twist to the question as to why Australia has so many marsupials, but no members of such widespread placental groups as hoofed mammals, elephants, carnivores, or shrews.

Pascual R, Archer M, Jaureguizar EO, Prado JL, Godthelp H, Hand SJ. 1992. First discovery of monotremes in South America. Nature 356:704-706.

Summary. A fossil tooth discovered in southern Argentina has been identified as the tooth of an extinct platypus-like mammal. The platypus and the echidna are the only members of a group of egg-laying mammals

known as monotrernes. This is the first record of any monotreme occurring outside of the Australian region. It was found in Paleocene deposits, along with fossils of crocodiles, turtles, mangrove pollen, and at least three other types of extinct mammals. This discovery adds to the evidence for faunal similarity between Australia and South America.

TAPHONOMY

Allison PA, Briggs DEG, editors. 1991. Taphonomy: releasing the data locked in the fossil record. Topics in Geobiology, Vol. 9. NY and London: Plenum Press.

Summary. This book consists of 11 chapters by various authors, covering many interesting aspects of taphonomy. Topics include taphonomy of organic biomolecules, nonmineralized tissues, plants, shells and vertebrates. The effects of minerals on fossil preservation are discussed with respect to pyrite, phosphates, carbonates and silica. A final chapter deals with taphonomic comparisons between deposits and taphonomic trends in the fossil record.

Comment. The book contains much useful and stimulating material, and is recommended for anyone interested in the fossil record.

LITERATURE REVIEWS

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

A CREATIONIST BOOK FOR PUBLIC SCHOOLS

OF PANDAS AND PEOPLE: THE CENTRAL QUESTION OF BIOLOGICAL ORIGINS. 1989. P. Davis, D.H. Kenyon, and C.B. Thaxton. Dallas, TX: Haughton Publishing Company. 166 p. Cloth, $18.50.

Reviewed by L. James Gibson, Geoscience Research Institute

Many Americans feel that creationism should be discussed in high-school science classes. However, few textbooks are available that present a creationist view based on observations from science. Written to help fill that gap, this book is intended as a supplement to the biology textbook. The text attempts to provide evidence for intelligent design in nature, but does not discuss the potential religious implications of such a theory.

The book has a somewhat unusual organization. The first chapter is actually an overview of the material of the entire book. A little more than 25% of the book is devoted to this overview. Following this, six topics are treated in more detail, each in a separate "excursion chapter." These six chapters have the following titles: "The Origin of Life"; "Genetics and Evolution"; "The Origin of Species"; "The Fossil Record"; "Homology"; and "Biochemical Similarities." A brief, one-page glossary is included at the back of the book, followed by a short chapter entitled "A Word to the Teacher." The book is hard-bound, with a cover photograph of a giant panda. There is an index, and the book is well-illustrated. A seven-page Teacher's Guide contains a well-prepared list of study goals and discussion questions.

The treatment of the origin of life is well done and includes a discussion of the Miller-Urey experiments and the proteinoids of Sidney Fox. The authors conclude that life is most reasonably explained as the result of intelligent design. Mutation, natural selection and adaptation are the topics of the second "excursion chapter." Intelligent design seems the best explanation for the existence of biological adaptations such as

the neck of the giraffe and certain plants known as "living stones." The following chapter discusses genetic drift and reproductive isolation, and concludes that speciation is generally accompanied by genetic loss rather than genetic gain. Intelligent design is the best explanation for the origin of genetic information, with subsequent genetic loss accounting for the relatively minor changes seen in species.

In a chapter on the fossil record the authors point out that most phyla originate early in the fossil record, which is just the opposite of what would be expected if species originated by progressive evolutionary development leading toward greater complexity. The lack of change within fossil "lineages" and the existence of gaps between fossil groups are also emphasized. Examples of gaps include the same examples usually presented by evolutionists as evolutionary links, such as *Archaeopteryx*, the therapsid reptiles, and *Australopithecus*. The distinction between intermediate and transitional fossils, made in the discussion of *Archaeopteryx*, is a particularly helpful concept.

The problem of accurate identification of homologies is illustrated in the fifth "excursion chapter." Non-homologous similarities, such as between the Tasmanian "wolf" and the ordinary wolf, or between the red panda and giant panda, are described. Similarities in organisms can just as easily be interpreted as the result of intelligent design. The discussion of similarities in organisms is extended to biochemical similarities in the next (and final) chapter. The failure of molecular sequences to form a series of intermediates is underscored in this chapter, using cytochrome c as an example. The molecular clock hypothesis is briefly explained and rejected. In the conclusion, the authors acknowledge that no theory of origins is complete and without problems, but point out there is impressive evidence to support the theory of intelligent design.

Naturally, the book is not free of errors. I found several typos, some of them annoying, but perhaps this is to be expected in the first edition of a book. Of more concern were the few, relatively minor, errors of fact present in the book. However, I did not find any errors that would materially affect either the conclusions of the authors or the arguments used to support the conclusions. In several places, statements were made for which references were not supplied. I was unable to locate the footnotes until I accidentally discovered them in the Teacher's Guide.

There are other places where the text could be improved, but this should not obscure the fact that there is much useful material in the book. It is attractively designed, and generally presents good arguments for the characteristics of life as strong evidence for the origin of life as a result of intelligent design rather than by purely natural processes. The authors leave open the question of the age of life, recognizing that adherents of the theory of intelligent design do not all agree on this question. Fortunately, another book is available which discusses this question within a biblical context (Webster 1989). I would not want to be without both these books for teaching secondary-school biology.

Of Pandas and People provides a fair-minded, non-sectarian discussion of evidence for origin by intelligent design that should be suitable for every public school.

LITERATURE CITED

Webster CL. 1989. *The Earth: Origins and Early History.* Distributed by the Office of Education, North American Division, General Conference of Seventh-day Adventists, 12501 Old Columbia Pike, Silver Spring, MD 20904-6600.

GENERAL SCIENCE NOTES

CLASTIC PIPES AND DIKES IN KODACHROME BASIN

By Ariel A. Roth, Geoscience Research Institute

In the region of the Kodachrome Basin State Park, Utah, are found some unusual vertically oriented, intrusive sedimentary structures. They are called pipes if cylindrical in shape (see Figure 1), or dikes if flat-like in shape. These structures, which sometimes reach heights well over 50 m (150'), have come from the sedimentary layers below. In the same area, there is also indication of collapse of some sediments into lower layers (Christiansen 1952).

These features in the Jurassic layers raise interesting questions regarding the amount of time involved in their formation. The source layers would have to be soft in order to intrude into other layers. Sediments cannot remain soft forever; they tend to become cemented.

FIGURE 1. One of the largest exposed "pipes" in Kodachrome Basin. The surrounding rock, which is softer, has been eroded away, leaving this 50 m (150') "monolith." The surface of the pipe is badly eroded.

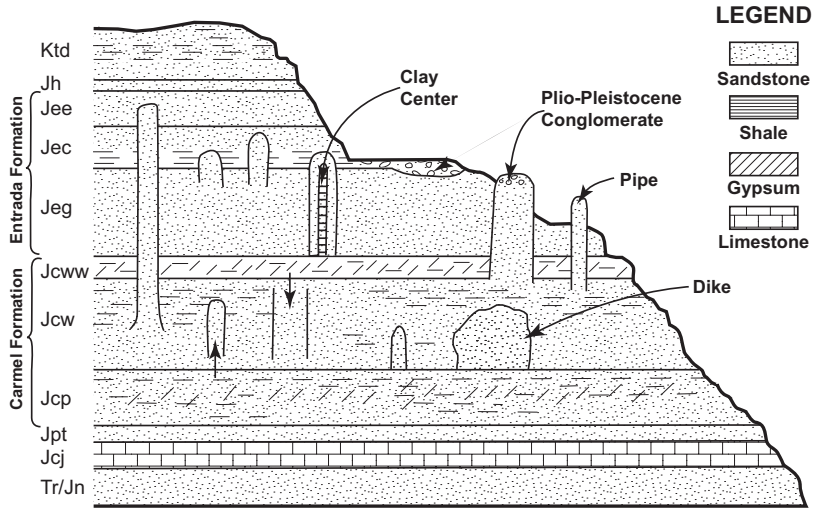


FIGURE 2. Diagrammatic representation of a section through the pipe and dike-bearing strata in Kodachrome Basin. Legend for formations: Tr/Jn — Triassic-Jurassic Navajo; Jcj — Jurassic Carmel, Judd Hollow; Jpt — Jurassic Page Sandstone, Thousand Pockets Tongue; Jcp — Jurassic Carmel, Parla River Member; Jcw — Jurassic Carmel, Winsor Member; Jcww — Jurassic Carmel, Wiggler Wash Member; Jeg — Jurassic Entrada, Gunsight Butte Member; Jec — Jurassic Entrada, Cannonville Member; Jee — Jurassic Entrada, Escalante Member; Jh — Jurassic Henrieville Formation; Kdt — Cretaceous Dakota-Tropic Formations undifferentiated.

Cementation occurs when dissolved minerals are carried by water into the sediments, hardening them into rocks. Some other features of these pipes also suggest that there was not much time between deposition of these layers and recent (Plio-Pleistocene) geologic activity. The conundrum is that the standard geologic time scale implies well over 150 million years between laying down of these sediments and what appears to be the time of intrusion.

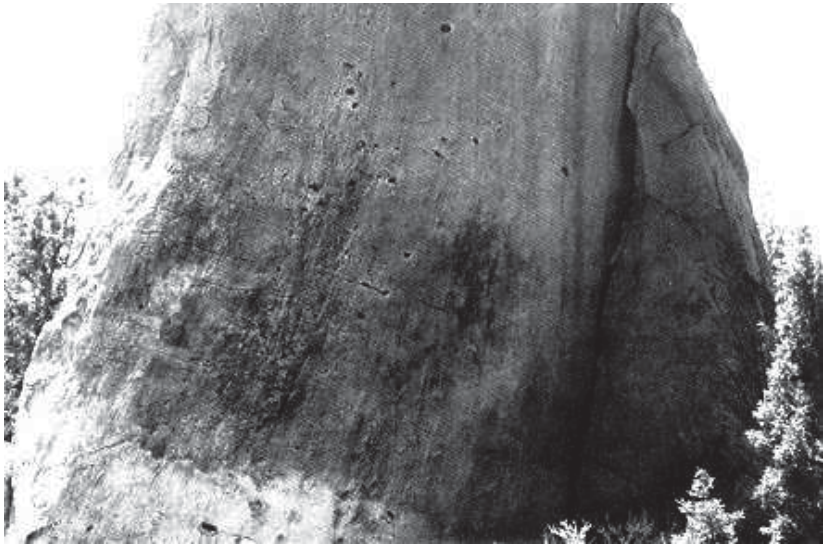
The details of these strata, which are about 600 m (2000') thick, have been worked out by Thompson and Stokes (1970) (see Figure 2). The Jurassic layers involved have a putative age of 144-208 million years. The Carmel Formation of this group averages around 179 million years, and the Entrada averages around 166 million years. In parts of the area an unnamed Plio-Pleistocene channel and sheet conglomerate (Gregory 1951) covers various formations. It contains basalt pebbles con-

sidered to be only 1-6 million years old, and therefore is interpreted to be much younger than the main Jurassic sedimentary formations of the area.

Hornbacher (1984) has mapped and described 67 pipes and many dikes in the area. They are found at various stratigraphic levels, but dominate in the Gunsight Butte member of the Entrada (Figure 2). One intrudes as far up as the Escalante member of the Entrada. The pipes range up to 52 m (170') in exposed height and up to 15 m (50') in diameter. Analysis of the rocks and minerals in the pipes shows similarity, mainly to the upper Paria River and lower Winsor Formations below. They are the most likely source for most of the pipes. Some upper Winsor and Thousand Pockets Tongue of the Page Sandstone (see Figure 2) and possibly other layers have occasionally also served as source for the pipes.

The mechanism for intrusion is problematic and may never be known. Hannum (1980) has suggested that the pipes came from cold springs. Hornbacher (1984) favors seismically induced sediment liquefaction and intrusion. The relatively smooth and striated wall pattern of some pipes (Figure 3) favors the latter interpretation. To add to the

FIGURE 3. Closeup view of the surface of one of the pipes showing vertically oriented striations. The slightly darker vertical rock wedge to the right is not part of the pipe but a remnant of the surrounding "rock" into which the pipe intruded.



mystery, there seems to be little or no disturbance of bedding planes or indication of compressive strain in the sediments surrounding the pipes. This suggests that both the pipe material and the surrounding sediments were soft when the pipes formed.

Hornbacher (1984) gives evidence that intrusion took place at the time of the recent Plio-Pleistocene conglomerate deposition. This includes: 1) intimate association of the Plio-Pleistocene conglomerate with the top of one pipe; 2) fluid escape structures from this pipe into the conglomerate; and 3) the Plio-Pleistocene tectonic activities in the region (i.e., earthquakes, orogenies) needed for the suggested mechanism of intrusion. LeFevre et al. (1987) suggest a Jurassic age for formation of the pipes, but give no direct supportive evidence.

These pipes appear to present a problem for the standard geologic time scale, since it would require that the Jurassic formations which serve as source for the intrusions remain soft (uncemented by minerals) for over 150 million years. Considering how easily cementing minerals are transported through sediments by water, this seems highly unlikely. It also seems highly unlikely that a delithification process (dissolving of cement) would take place at the same time throughout the thick and highly varied sequence over the widespread area in which these pipes are found.

Even if one does not take into consideration the evidence for a Plio-Pleistocene intrusion, there is still a problem for the standard geologic time scale. The time, represented by the vertical distance between the source of the pipes and their present location, would be many millions of years (13 million if you use the average Carmel and Entrada ages). It seems very unlikely that the source material could remain uncemented for that length of time. Some of the pipes intrude 100 m (300') of sediment.

One can argue that since there are now soft sediments on the ocean floor which are assumed to be many millions of years old, the sediments producing the pipes and the surrounding rocks could have likewise remained soft for many millions of years. However, the situation associated with these pipes does not appear to be comparable. Some of the layers associated with the pipes are interpreted as being terrestrial instead of marine. We do not now see in the continental crust older layers in a fluid state that could form the pipes. Associated with these pipes and dikes are long fine veins originating from the pipes and penetrating the surrounding layers. These seem to mandate a highly fluid source (i.e., the pipes themselves). However, it seems virtually

impossible for the intruding material in these veins to have remained soft for any extended period of time. An overburden of more than 1200 m (4000') of sediment once covered the now-exposed area where these pipes are found. This overburden would create a pressure of 275×10^5 Pascals (4000 lb/in^2). Such pressure would induce rapid cementation, precluding a Plio-Pleistocene intrusion.

These pipes are fascinating structures. The model of formation that seems to best fit the data would be rapid deposition during the recent Genesis flood, with subsequent seismic activity liquefying uncemented sediments which would then intrude into the overlying soft sediments, forming the pipes and dikes.

REFERENCES

Christiansen FW. 1952. Slump structures and associated "clastic intrusions" in Upper Jurassic sediments, Kane and Garfield Counties, Utah. Geological Society of America Bulletin 63:1359.

Gregory HE. 1951. Geology and geography of the Paunsaugunt region, Utah. U.S. Geological Survey Professional Paper 164.

Hannum C. 1980. Sandstone and conglomerate — breccia pipes and dikes of Kodachrome Basin area, Kane County, Utah. Brigham Young University Geology Studies 27:31-50.

Hornbacher D. 1984. Geology and structure of Kodachrome Basin State Reserve and vicinity, Kane and Garfield Counties, Utah. M.A. Thesis. Loma Linda University.

LeFevre LM, Pollock GL, Lohrengel (II) CF. 1987. Geology of Kodachrome Basin State Park. Encyclia 64:114-120.

Thompson AE, Stokes WL. 1970. Stratigraphy of the San Rafael Group, southwest and south central Utah. Utah Geological and Mineralogical Survey Bulletin 87.

EDITORIAL

FOSSILS AND COMPASSION

In the world of paleontology, few names evoke more derision than that of Johann Bartholomew Adam Beringer. Nevertheless, this learned man, who lived in the 18th century, had impressive credentials. He was dean of the Faculty of Medicine at Würzburg in Germany, chief physician to the prince-bishop of the town, as well as chief physician of the Julian Hospital. He had broad interests, was an indefatigable scholar, lectured on a variety of subjects, and wrote several volumes including one entitled *Lithographiae Wirceburgensis*, which propelled him into infamy. This interesting treatise described special stones that had been collected in the field, including many fossils as well as other meaningful finds which often ended up in his personal collection. In his book were descriptions of peculiar stones with representations of birds, bees, flowers, spiders, Hebrew alphabet characters, the moon, stars, and the rising sun.

Beringer discussed at length various ideas regarding the possible origin of these special stones, and felt that they probably represented some kind of natural phenomenon. He especially denied that they could have been artificial or some form of "modern art."

Popular history recounts that shortly after the publication of his book in 1726, he was collecting in his favorite locality on Mount Eivlstadt, near Würzburg, when he discovered a stone with his own name carved on it. The horrified Beringer then realized that he was the victim of a cruel hoax and that a number of the special stones he had described in his book were nothing else but fabrications by some imposter who had hidden them in his collecting area. The tragic accounts usually report that some of his students had purposefully tricked him, and the hapless and mortified Beringer ruined himself financially trying to buy back all the copies of his book that had already been sold. Shortly after that, he became so discouraged that he died of chagrin. The trick had worked too well.

Beringer has become a symbol of the gullible, and, too often in academic circles, an object of humorous mockery. His other volumes are of little interest, but extant copies of his book on stones are highly valued among bibliophiles and command a very respectable price. Some of the fabricated stones, or "Lugensteine" (lying stones), as they became known, are still in existence and of considerable value.

In reality, part of the derision bestowed on Beringer is apocryphal. Documents discovered in Würzburg in 1935 and studied several years later show that the popular accounts are somewhat erroneous.[1] His students did not plan the clandestine operation that tricked him into embarrassment. Instead, the culprits were two jealous colleagues at the University of Würzburg: J. Ignatz Roderick, a professor of geography, and Georg von Eckhart, a librarian. Soon

after the publication of his *Lithographiae Wirceburgensis*, Beringer took these two individuals to court to preserve his honor, and they were appropriately punished. Beringer did not die of chagrin, but lived for some 14 years after the discovery of the cruel prank and maintained professional status at least during part of that time. Likewise the account of his having found a rock with his own name on it has never been substantiated.

From what remains of the story, it appears that Beringer exercised poor judgment, at least by comparison with 20th-century thought patterns. One must remember that the Beringer incident took place in the early 18th century, when a variety of basic philosophical ideologies were competing, and the world of intellectual ideas was in great turmoil.

Clearly Beringer is not unique in the misidentification of fossils. As one small example, the venerable *Treatise on Invertebrate Paleontology*[2] lists some 50 published descriptions of "fossil organisms" originally identified as coral, algae, fungi, sponges, snails, etc., that are most likely of non-biological origin. They appear to be produced by unusual depositional events in sediment, drag marks, precipitation, or the reorganization of minerals after sediment deposition.

Some aspects of paleontology are highly interpretive because they deal with a past that is difficult to verify. They are thus vulnerable to misconceptions. Needless to say, the study of fossils is not the only area of inquiry prone to error. There are many other disciplines that are more or less subjective and face the same problem.

While errors such as those made by Beringer must never be condoned, we do not have the right to exaggerate the errors of others and make our fellow human beings a laughingstock. More compassion towards Beringer would have prevented the cruel tricks played on him and would have reduced the unwarranted denigration of his infamous book.

We all make mistakes. Recognition of this should produce a compassionate attitude towards the errors of others and towards views that differ from ours. Such an attitude fosters both accuracy and the understanding of alternative viewpoints.

"Treat men exactly as you would like them to treat you."[3]

Ariel A. Roth

ENDNOTES

1. Details of this peculiar incident, as well as transcripts of pertinent court proceedings, are given in: Jann ME, Woolf DJ. 1963. The lying stones of Dr. Johann Bartholomew Adam Beringer. Berkeley and Los Angeles: University of California Press.
2. Treatise on Invertebrate Paleontology. 1962. Part W: Miscellanea, p W232-238. Geological Society of America and University of Kansas Press.
3. Jesus Christ in Luke 6:31. J. B. Phillips revised translation. 1972. The New Testament in modern English. NY: The Macmillan Company.

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: Aardsma: Letter to the Editor (ORIGINS 18:6-7)

A typographical error appeared in my letter, which may cause some readers some confusion. The number "7500" should have been "5700." The sentence containing this difficulty should read as follows:

> *The C-14 age of the first growth ring of this tree is roughly 5700 B.P., while that of its final growth ring is roughly 6150 B.P.*

The mistaken number (7500) leads to the perplexity of how there could be only 580 rings in 1350 radiocarbon years.

I appreciated Dr. Brown's response to my letter, but was disappointed in its lack of documentation regarding his thoughts on Jericho. Though I have read extensively about the excavation at Jericho (because of the prominent place it holds in establishing a proper date for the Exodus and Conquest), I have never come across anything to what Dr. Brown is suggesting. I join with Dr. Brown in hoping that a competent archaeologist will discuss this matter in ORIGINS in the future.

Gerald E. Aardsma
Coordinator of Research
Institute for Creation Research
Santee, California

ARTICLES

SOCIOBIOLOGY: THE EVOLUTION THEORY'S ANSWER TO ALTRUISTIC BEHAVIOR

Leonard R. Brand
Professor of Biology and Paleontology
and
Ronald L. Carter
Professor of Biology
Loma Linda University
Loma Linda, California

WHAT THIS ARTICLE IS ABOUT

Sociobiology is a hotly debated theory which proposes to explain the evolution of behavior. The debate, especially as it deals with the application of sociobiology theory to humans, has been the cause of much misunderstanding between scientists with different views on the subject. Sociobiology has important implications for the nature of man, and consequently it is important for a Christian who is searching for a strong foundation for moral values to understand those implications of sociobiology before deciding what to do with the theory. A theory is not necessarily all correct or all wrong, but must be analyzed with care. Could it be that sociobiology theory correctly describes some of the changes that have occurred, even in man, in a post-creation world in which mutations are affecting behavior as well as morphology, but not necessarily implying that major groups of animals have evolved from common ancestors?

What is morality? Does it have a biological basis? Currently much debate in society centers around the development of morality. Deciding what is right and wrong in the technologically complex world of today is sometimes difficult, even for those who accept biblical guidelines for behavior. Many individuals look to nature and science to find principles of ethical and moral behavior. The theory of sociobiology was developed in the search for a more adequate evolutionary explanation for all forms of social behavior — among animals, as well as humans. Sociobiological theories have been developed which supposedly provide an evolutionary

explanation for the roots of moral behavior and the development of altruistic-like behavior in both animals and humans.

Charles Darwin's theory of evolution was highly successful in winning support, because it offered a logical explanation for diversity within groups of organisms, and described the process of natural selection which in nature would favor individuals who were most fitted for survival. That mechanism as understood today can be summarized as mutation, recombination, excess reproduction, and natural selection.

Mutations, or alteration of genes, along with genetic recombination, increase the genetic variation in a population of animals. Many more individuals of each species are born or hatched than the environment can support, and since the individuals in the species are not all alike, some process must determine which ones will survive and reproduce. If a mutation changes the color of an animal so that it matches its background environment more closely, it will have a better chance of escaping detection by predators, and will be more likely to survive longer than its relatives who do not blend as well into their background. This process of natural selection was a key element of Darwin's theory.

Will that new color variant become common and eventually dominate the species, at least in its local environment? In order for that to occur, it is not enough for the individuals with the new color variation to live longer. Their impact on the next generation is determined entirely by how many offspring are produced that have the new color gene. The ability of organisms to reproduce successfully is described by the term "fitness." The individuals that produce the largest number of surviving and reproductively successful offspring are said to have the highest evolutionary fitness. Natural selection favors traits that increase the reproductive rate of an animal; or, in more technical terms, increase its fitness. It is not too difficult to see how this can work in selecting such morphological traits as selection among individuals with 1) color variations (improving camouflage); 2) variations in size or strength (ability to secure food and defend against enemies), or in speed (ability to escape). Could the same process be involved in explaining evolutionary changes in behavior?

In the 1950s and 60s the field of ethology — the study of the natural behavior of animals — was developing out of the pioneering work of three ethologists — Konrad Lorenz, Niko Tinbergen, and Karl von Frisch — who later shared the Nobel Prize in medicine. The work of ethologists brought to light the numerous and fascinating species-specific behaviors in animals that apparently are under genetic control. The fields of etholo-

gy and population biology began to be integrated and applied to the task of explaining the evolutionary principles controlling the complexities of animal social behavior (Fisher 1991).

Could the process of natural selection provide an adequate explanation for the origin of the behavior of animals? Could it explain why some species have monogamous mating systems and some are promiscuous, or why some species rely more on sound communication and some focus on chemical communication? Ewer (1968, p x) summarized the challenge with his statement that "unless the mechanisms which produce the behavior are explicable in terms of natural selection working in the orthodox manner, we will be forced to postulate special creation or some unknown mystical-magical process." In many cases, convincing microevolutionary explanations could be given. A very sticky problem remained, however, in attempting to explain altruistic behavior. Strict Darwinian reasoning would predict that an individual animal would compete to survive rather than act selflessly toward other individuals, especially if that act may put its own fitness into jeopardy.

An altruistic act is any behavior that benefits another individual at the expense of or risk to the one performing the behavior. For example, a ground squirrel that gives an alarm call when a hawk appears will warn others to hide, but it also draws attention to itself, and may even increase the chances that it will be the one caught by the hawk. In evolutionary terms a squirrel that is prone to give alarm calls may be decreasing its own fitness, because it is decreasing the probability that it will live to reproduce. A squirrel whose genes predispose it to cheat, by benefiting from the alarm calls of others without giving calls itself, would appear to be the one with the best chances of reproductive success, and thus the highest fitness.

There are some species of birds, such as the Florida Scrub Jay and the African bee eaters whose nests are cared for by the parents with the assistance of one or more other adult "helpers at the nest." Why would one of these helpers decrease its own fitness by helping other birds raise their young, rather than making its own nest and raising young that carry its own genes?

An extreme example of apparent altruism is found in the social insects of the Order Hymenoptera — the ants, bees, and wasps. Most of the individuals in a honey bee hive, for example, are workers, or females that do not produce any offspring of their own but spend their lives helping the queen to raise her offspring. It would appear that the

workers' fitness is zero. If this is so, it would also appear that natural selection would favor any worker with altered genes that allowed it to produce its own young.

Many who accept some form of creation by God consider the creation of man and morality to have been a separate and special act from other acts of creation. It is therefore tempting for a creationist to simply dismiss any evolutionary claims for possible mechanisms to explain what appear to be altruistic behaviors. However, even creationists who believe that true altruistic behavior was common in animals and humans as originally created must explain why post-creation genetic mechanisms have not eliminated altruistic behaviors. Thus the question regarding the existence of altruism in animals remains essentially the same for everyone, no matter what philosophy they start from.

SOCIOBIOLOGY: A PROPOSED ANSWER TO ALTRUISM

In 1975 the Harvard entomology professor Edward O. Wilson published a book entitled *Sociobiology: the New Synthesis*. In this book he developed a new paradigm which he defined as "the systematic study of the biological basis of all social behavior," "a branch of evolutionary biology and particularly of modern population biology." This paradigm stimulated a considerable amount of controversy, but in large measure has been generally accepted. "In 1989 when the fellows and officers of the Animal Behavior Society were asked to name 'the most influential book in animal behavior in the last 20 years,' their overwhelming choice was *Sociobiology*" (Fisher 1991).

In *Sociobiology* Dr. Wilson proposes to have solved the problem of altruism. A cornerstone of sociobiology theory is the concept of inclusive fitness, which in simple terms refers to the rate at which an animal's own offspring and its close relatives' offspring (who share many of its genes) are successfully reared to reproductive age. While *fitness* is an animal's rate of success in passing its genes directly to its own offspring, that animal's *inclusive fitness* is its rate of success in passing its own genes directly to its offspring and indirectly to the offspring of its close relatives, because its relatives have many of those same genes. Two sisters share, on the average, 50% of their genes in common. If one sister helps the other to successfully raise her offspring to reproductive age, she assists in passing on many genes that she shares with her nephews and nieces, thus increasing her inclusive fitness. There will be more genes like hers in the next generation if her sister is success-

ful, than there would be if her sister is not successful in helping her young to survive.

With this concept of sharing genes among relatives, sociobiology theory predicts that altruistic behavior should exist only in situations in which the "altruistic" individual would actually increase its inclusive fitness by that behavior. The biologist J. B. S. Haldane once said that he would lay down his life for two brothers or eight first cousins. His reasoning was that brothers share, on the average, half of their genes, and first cousins share one eighth of their genes. If Haldane died for one brother (thus eliminating his own chance to reproduce), this brother could only pass on half as many of J. B. S. Haldane's genes as J. B. S. himself could have done. However, if he died to save two brothers, in terms of statistics he would come out even, since they could still pass on as many of his genes as he could have done himself (Fisher 1991).

If we apply this principle to our alarm-calling squirrels, sociobiology theory predicts that squirrels should be most likely to give alarm calls in situations in which they are surrounded by many close relatives, so that the squirrels that are helped by the calls will share many genes with the caller, thus increasing the caller's inclusive fitness. Research has shown this to be true. When young ground squirrels mature, the males disperse to distant places before they settle down and choose a territory. Young females set up territories near home. Consequently, females have many close relatives living near them, but males do not. Just as the theory predicts, it is the females who give the alarm calls, and many of the squirrels who are helped will be relatives who share her genes. Even if she is caught by the predator, her relatives who run for cover will pass on the genes that caused her to give the alarm call (Holmes & Sherman 1983, Sherman 1977).

When natural selection is applied to this situation in which genes are passed on through relatives, it is called kin selection — selection that acts on individuals and their families. Favorable traits are shared by close relatives (kin; family members), and families that have such favorable traits in their behavior — that assist other family members to survive — will have more reproductive success than other families. Their behavioral traits are the ones that will survive.

Can sociobiology also explain the helpers at the nest? Kin selection would predict that a bird nest will have non-parent adult helpers only when the helpers are close relatives of the nest owner, and only in situations in which the helpers' inclusive fitness will he higher from

helping relatives than from trying to raise their own young. Research has confirmed that this prediction is correct (Krebs & Davies 1987, p 270-276; Fisher 1991) for the Florida Scrub Jay and the African bee eaters, and that the helpers are close relatives, usually offspring from a previous season helping their parents. They cannot secure territories of their own, or are too inexperienced to be very successful in raising their own young; so until they are ready to do so, their inclusive fitness will be higher if they help raise their relatives who share many of their genes than if they try to produce their own young.

On the African plains are two species of social animals which act very differently when their young are attacked by predators. Zebras will try to defend each other's young, but wildebeests do not. Sociobiology would predict that this behavior indicates that zebras are more likely than wildebeests to be in the company of close relatives, and research has confirmed that explanation. Zebras generally stay in family groups, whereas wildebeests wander randomly within the very large herd and do not stay together as families. Consequently, if a zebra sees a nearby baby being attacked, that baby is likely to be close kin, and it would increase the adult's inclusive fitness to save the baby. However, a wildebeest in that same situation would not improve its inclusive fitness by being heroic, because the baby is not likely to be a close relative (West-Eberhard 1975).

Even the seemingly impossible case of the honey bee workers is, on closer inspection, explained by kin selection. In the reproduction of the social bees, ants, and wasps there occurs a phenomenon called haplodiploidy. Females develop from fertilized eggs in the usual way. Males of these groups, however, develop from unfertilized eggs. While females have diploid chromosomes, males have only haploid chromosomes. When males mate, they contribute all of their alleles, instead of only half, as would occur if they were diploid. A result of this scheme is that each female offspring shares half of her mother's alleles, but all of her father's alleles. Another result is that sisters have 75% of their alleles in common, or have a relatedness of 75%, rather than the 50% relatedness that results from the more common diploid arrangement. The simple mathematics of this system indicate that a worker (female) passes on more of her genes by helping to rear her sisters than by rearing her own offspring, at least in a colony that produces more females than males (Fisher 1991, Trivers & Hare 1976).

The processes of *mutation* and *kin selection* and their effects on *inclusive fitness* are the basic elements of sociobiology theory, and are the elements of the mechanism by which sociobiology proposes to explain the origin of altruism and all other social behavior. According to this theory all behavior is the result of evolution. Sociobiology theory says that the entire focus of life is reproductive success; animals are "sex machines" (Anderson 1982) whose function is to pass on those favorable genes that will improve the inclusive fitness of their offspring.

The evolution process has no room for unselfish actions that help a non-kin at the expense of the one performing the action, and thus one corollary of sociobiology theory is that there is in fact no such thing as truly altruistic behavior. Some apparent exceptions to this are explained as *reciprocal altruism*: "You scratch my back and I'll scratch yours."

For example, olive baboon males will solicit help from an unrelated male in an aggressive interaction against a third male. It often occurs that on another occasion the roles will be reversed, and the original solicitor will help the same partner who is now the solicitor (Packer 1977; see also Trivers 1971). In the behavior of non-human animals the theory has been quite successful in explaining how apparent altruistic behaviors can be actually favored by kin selection and may be explained without invoking the assumption of altruism at all.

BEHAVIORAL STRATEGIES

As animals compete with each other for resources such as food, living space, or mates, various behavioral strategies could be employed, and the application of sociobiology theory suggests ways to predict which strategy will be most effective in different situations. For example, two competitors could simply fight, with the winner of the fight taking the resource, or they could employ some type of conventional strategy (symbolic battle), like a stereotyped arm-wrestling match that indicates which animal is stronger or more aggressive without the risk of anyone getting hurt. Game theory, and the principles of sociobiology can be used to predict the benefits of each strategy (Krebs & Davies 1987, p 134-160). In general, natural selection (including kin selection) is expected to favor conventional strategies over all-out "war" in animal conflicts (Maynard Smith & Price 1973).

Many examples of this can be seen in nature. Male rattlesnakes wrestle with each other, and the winner is the one that can pin the other's head to the ground with his own body. Some lizards "battle" by

hitting each other with their tails, or by butting their heads together and trying to push each other backward. Deer and antelopes have potentially lethal antlers or horns, but when the males battle over mates they do not try to impale each other. They butt their heads together and wrestle in ways that usually do not cause serious damage (Wallace 1973, p 221-229). Animals also commonly use aggressive displays to communicate the nature of their aggressive state to other individuals of their species. This apparently allows the other individual to respond appropriately, thus reducing the amount of fighting (Drickamer & Vessey 1992, p 211, 220, 237-255; Marler & Hamilton 1967).

On the other hand, there are some specific situations in which more destructive tactics are used, and are thought to be favored by selection. Research under the guidance of sociobiology theory has led ethologists to recognize the role of some animal behaviors that were previously thought to be only bizarre abnormalities. For instance a male African lion will sometimes kill all the babies in his pride. If there is a battle between males in which the ruler of the pride is deposed, the new dominant male will generally kill all of the young, the offspring of his deposed rival. Consequently he will be able to mate and produce his own offspring much more quickly than if the females were occupied with offspring of his former rival (Bertram 1975). Such infanticide is also known to occur in Hanamun langurs, mountain gorillas, chimpanzees, African wild dogs, and rodents (Fisher 1991).

Some research data are difficult for sociobiology to explain, but it appears to us that sociobiological reasoning provides in many instances useful and testable scientific predictions in animal behavior studies.

IMPLICATIONS FOR HUMAN BEHAVIOR

Sociobiology has become the prevailing synthesis in the study of animal behavior, and would seem to be very successful in explaining the behavior of the many animal species to which its principles have been applied. What are its implications for human behavior? Most researchers do apply sociobiology to the study of human behavior, and if that application is correct, this theory has enormous implications for the nature of man.

A basic claim of sociobiology is that human behavioral traits are not a result of special creation, but are genetically and environmentally determined and have developed through evolution from non-human ancestors. Human behavior is assumed to be the direct result of kin

selection combined with cultural evolution. The ultimate object of that behavior, important elements of which are programmed into each individual's genes, is the maximization of his or her inclusive fitness. If the human species were the result of an evolutionary origin, it would be difficult to escape such a conclusion.

Increased inclusive fitness is gained by increased reproduction by oneself or one's close relatives. Consequently, according to sociobiology, reproductive success is the dominant factor determining human behavioral tendencies, and though we may think that we are rational, moral beings, our behavior is more programmed than we think it is. In other words, "sociobiologists contend, we were designed to be reproduction machines" (Anderson 1982).

Many Christians believe that mankind has been given a set of moral rules for sexual behavior. These rules tell us what is right or beneficial, and what behavior is wrong and is to be avoided simply because it is damaging to human relationships or will harm ourselves or others. Sociobiology says there are no morally right or wrong behaviors; our behavior is determined by the selection pressures that have created us. One author has summarized the concept this way:

> *The type of man who leaves the most descendants is the one who cuts his reproductive costs on all sides, by keeping a close watch on his mate and making sure he has no rivals; supporting his mate, if it seems that all her children were sired by him; and mating with other females — additional wives, single women, other men's wives — whenever a safe opportunity arises* (Anderson 1982).

It has been recognized that society has tended to have a double standard; being more tolerant of sexual promiscuity in males than in females. Sociobiology says that the double standard has a biological basis — it is not moral or immoral; it simply is a strategy that produces more children. It also has a deeper biological basis. A female produces a small number of eggs in her lifetime, and when one of them is fertilized she puts a tremendous amount of energy into the production and rearing of that offspring. Males, in contrast, produce millions of sperm continuously, and although males may be involved in helping to care for the young one, they do not directly put any significant amount of energy into producing the baby. Thus a female has a much greater investment in her offspring than a male does, and has much more to lose by making mistakes in her reproductive effort. Also, since a female produces the

baby in her own body, she has no doubt which offspring are hers, whereas a male, unless he knows that he can trust his wife, does not have any innate way to know for sure that any given offspring is really his. Thus the double standard — a female's reproductive success will be advantaged if she is faithful to the male who is helping her raise her offspring, but since the male cannot be sure which children are his, his best strategy for maximizing his reproductive fitness will be to spread his genes around to a number of women (Anderson 1982). Other authors suggest that promiscuity is advantageous for females as well (Bellis & Baker 1990).

Why do men rape? "New sociobiological analyses conclude that rape evolved as an adaptive strategy benefiting males who had lost out in the competition for mates." Though it is recognized that rape is often more of an act of violence than a sexual act, it is concluded that rape was originally programmed into our behavior because of the reproductive advantage to the rapist (Nalley et al. 1982).

Many human societies tend toward polygamy rather than monogamy. Is this behavior morally wrong, resulting from human sinful nature, or is it an evolutionarily advantageous strategy? A woman's reproductive output may not be reduced by being in a polygamous family, but a male's reproductive output could definitely be increased by being polygamous (at the expense of other males who lose in the competition for mates). Consequently, says E. O. Wilson, "fidelity ... evolves only when the advantage of cooperation outweighs the advantage of seeking extra mates" (Nalley et al. 1982).

SOCIOBIOLOGY: AN ALTERNATIVE TO RELIGION

These examples illustrate that in sociobiology theory there is no right or wrong behavior in a moral sense, only different behavioral strategies with different effects on inclusive fitness. Sociobiology could be said to be the naturalistic answer to Christianity's value system. In fact it attempts to answer the same great questions that Christianity addresses. In an interview, E. O. Wilson stated that sociobiology is "important because it addresses the most fundamental questions of humanity: Who are we? Where did we come from? Where do we want to go? How do we get there?" (Anderson 1982). When asked what we should do with sociobiology (i.e., what are the answers to some of those questions?), Wilson said, "I don't want to seem to be avoiding the question. But I can't answer that now — we don't know enough. We'll have to feel our way as we go along" (Anderson 1982). The fact is that

Wilson has already given his answer: mankind "lacks any goal external to its own biological nature" (Wilson 1978).

Christians would do well to be aware that sociobiological claims appear to replace the core of the Christian belief system. "Wilson openly challenges Christian faith by offering a substitute belief system based upon scientific materialism" (Rothrock & Rothrock 1987). Wilson believes that man has an innate tendency toward religious belief, because in the past it conferred an adaptive advantage. He also believes that the content of religious belief is false, and that we should develop a more correct mythology, which will take the place of Christianity (Rothrock & Rothrock 1987). "This mythopoeic drive (i.e., the tendency toward religious belief) can be harnessed to learning and the rational search for human progress if we finally concede that scientific materialism is itself a mythology defined in the noble sense" (Wilson 1978). He urges us to "make no mistake about the power of scientific materialism. It presents the human mind with an alternative mythology that until now has always, point for point in zones of conflict, defeated traditional religion" (Wilson 1978).

Wilson does not deny that religion and religious moralism have any value. He believes that they can encourage reciprocally altruistic behavior by discouraging cheating. If a person is saved from drowning, he could accept the benefit of his rescue, but cheat the system by refusing to take the risk involved in helping his benefactor out of a similar difficulty. Wilson (1980a) states that the answer to this possibility is that "in an advanced, personalized society, where individuals are identified and the record of their acts is weighed by others, it does not pay to cheat even in the purely Darwinist sense." "Aggressively moralistic behavior, for example, keeps would-be cheaters in line — no less than hortatory sermons to the believers."

A major difference between this view and what Wilson calls traditional religion or fundamentalist religion is that to the scientific materialist the decision as to what behaviors should be encouraged should be based entirely on scientific findings, especially on an understanding of man's evolutionary history, and not on religious input. Wilson feels that as more scientific information becomes available, it would seem "far better to make final decisions concerning social control (of moral behavior) by democratic consensus, not by religious or ideological dogma" (Wilson 1980b). He further states that "science has demythologized most of human experience by disproving traditional religious accounts of the origin of the world and substituting in their place a network of precise and experimentally testable, materialistic explanations. The discussion

of interest now is between scientists and liberal theologians." He does not define his usage of the term "liberal theologian," but the context indicates that, as Wilson understands it, such persons would accept an evolutionary origin of man, but would still argue for some type of communication from a supreme intelligence into the deep recesses of the mind. He is confident, however, that as science makes progress in its study of the human mind, it will disconfirm the hypothesis of input from a transcendent god (Wilson 1980b).

Wilson has said that "fundamentalist religion ... in its aggressive form is one of the unmitigated evils of the world" (Wilson 1980b). He feels that the answer to this problem comes from science, which offers the "possibility of explaining traditional religion by the mechanistic models of evolutionary biology.... If religion, including the dogmatic secular ideologies, can be systematically analyzed and explained as a product of the brain's evolution, its power as an external source of morality will be gone forever" (Wilson 1978). One of the areas that Wilson feels should be changed is that our ideas of sexual morality should be more liberal. He bases this conclusion on a survey of the behavior of our presumed non-human ancestors and on his convictions that Christianity's moral laws did not come from God (Wilson 1978).

Some current ethics books are based on the principles of sociobiology. For example, both *Search for a Rational Ethic* (Snell 1988) and *The Biology of Moral Systems* (Alexander 1987) base their ethical systems on the assumptions that man has evolved from other primates and that we must look to that evolutionary history and the principles of sociobiology to develop ethical principles for humans to follow. Both books, especially Snell (1988), at times refer to concepts from the Bible and other religious books, but only as far as the authors feel that those concepts are supported by evolutionary principles. Their standard for making ethical decisions is clearly humanistic, evolutionary thinking. Religion, to them, is a human invention. Alexander (1987, p 207) states that "Gods are inventions originally developed to extend the notion that some have greater rights than others to design and enforce rules."

Alexander (1987, p 3) concludes that "despite our intuitions, there is not a shred of evidence" to support the view that humans now and then engage in genuinely altruistic acts. Both Alexander (1987) and Snell (1988) explain all seemingly altruistic human behavior on the basis of reciprocal altruism — our instincts have been fine-tuned by evolution to recognize when it is in our own best interests to do something good

for someone else. Alexander (1987, p 253) concludes that conscience is "the still small voice that tells us how far we can go without incurring intolerable risks. It tells us not to avoid cheating but how we can cheat socially without being caught." Alexander (1987, p 19) also accepts the conclusions of other philosophers that "'pleasure' and 'happiness' [are] the leading candidates for the status of supreme goods or ultimate goals." He quotes a question asked by the philosopher MacIntyre who titled a paper "Crisis in moral philosophy: why is the search for the foundations of ethics so frustrating?" (Alexander 1987, p xiv). His answer is that the missing concept that others have left out is that human behavior is the result of evolution.

IS SOCIOBIOLOGY REAL?

To what extent are the proponents of sociobiology correct? In order to address this question, several different concepts can be isolated and dealt with separately.

1) The proposed naturalistic origin of the higher groups of organisms, including the origin of man and the human brain.

Sociobiology theory, as proposed by Wilson, is built on the assumption of the naturalistic evolutionary descent of all organisms from a common ancestor. Sociobiology by itself does not provide, nor claims to provide, evidence for that evolutionary descent, however. It merely assumes the naturalistic evolutionary origin of animals and develops hypotheses and explanations for behavioral changes which are based on that assumption. The question of whether the scientific data support the theory that humans evolved from non-humans and that the major groups of animals are also the result of evolution would have to be addressed through other areas of science than sociobiology, and are beyond the scope of this article. We will discuss a religious perspective on this issue below.

2) Kin selection and the evolution of behavior, at the level of species or genera of animals.

The evidence for this concept seems to us, in many cases, to be quite convincing. The non-reproducing worker bees, the alarm-calling female ground squirrels, the bird helpers at the nest, and a host of other examples certainly fit the theory very well. Whether future research will continue to support it as well remains to be seen; but with mutations causing random damage to the genes that influence behavior, it does

seem very likely that behaviors which are not supported by some type of selection process would eventually be weakened or eliminated by mutational damage. One possibility which sociobiology does not consider is the concept that animals were originally designed with more altruistic behavior, but those altruistic behaviors which are not favored by kin selection have been lost through the action of mutation and selection.

3) Kin selection and its genetic influence on human behavior: genetic control over human behavior.

Aside from the question of whether man is the result of evolution, it can be asked whether human behavior is controlled by genes, as claimed by sociobiology, or whether human behavior is mostly culturally determined — i.e., learned, rather than inherited. This has been debated ever since (and before) sociobiology was introduced. Wilson (1975) actually does recognize that culture is an important component of human behavior, but he maintains that there are also important themes of primate behavior that are present by inheritance in humans. Others disagree, including those scientists who believe that Wilson's sociobiology goes too far in presuming biological determinism. Perhaps the most widely known person in this group of challengers to biological determinism is Stephen J. Gould, a colleague of Wilson's at Harvard. Gould praised most of Wilson's sociobiology, but rejected what he saw as biological determinism in humans. He and others argue that there is no evidence for genes that determine human behavior and that the theory of such genes is not testable (Fisher 1991). When Wilson was scheduled to speak at the 1973 meetings of the American Association for the Advancement of Science, opponents of his theory "commandeered the podium ..., delivered a five-minute diatribe against him and his works, and concluded by pouring a pitcher of water over him as one heckler said, 'We think you're all wet'" (Fisher 1991). Unfortunately, the debate surrounding sociobiology has often created judgmentalism and overt emotionalism, rather than a dispassionate search for truth.

There are others who carry the concept of genetic control of human behavior farther than Wilson does (Barash 1979, Nalley et al. 1982, Anderson 1982, etc.) and who attribute to genes even stronger influence over human behavior.

In non-human animals there is evidence for genetic control of behavior (e.g., Bentley & Hoy 1972, Berthold & Querner 1981, Brandes 1991, Hirsch & McGuire 1982, Kyriacou 1990, Plomin, DeFries &

McClearn 1990, Provost 1991, Ricker & Hirsch 1988, Roubertoux & Carlier 1988), and consequently, even though much of human behavior seems to be modifiable by culture, the possibility that significant genetic control of behavioral tendencies exists in man needs to be considered. If such control exists, there is the strong possibility, perhaps certainty, that mutations could alter that behavior. With random genetic damage of genes occurring, it would be difficult to escape the conclusion that some human behaviors can be altered or eliminated by mutations and would be subject to the processes of natural selection, including kin selection.

CONCLUSIONS

Concepts of right and wrong for Christians are understood as a moral code given to mankind. The Ten Commandments and the teachings of Christ have provided a standard for human behavior, a standard that is God-given rather than innately produced. Christians have reason to believe that when humans were created, their behavior was naturally altruistic and in harmony with God's moral law, but that part of our altruistic tendencies has been lost. Sociobiology, on the other hand, states that there is no God-given moral law, and that human behavior has evolved from the behavior of our non-human ancestors and is not genuinely altruistic.

Christians can respond to the claims of sociobiology in various ways. Some may choose to view any aspect of evolutionary theory as anti-Scripture and therefore totally incorrect and worthless. Others see the utility of sociobiology in answering questions regarding social behavior of man and animals, including seemingly altruistic behavior, and may conclude that the concept of a God-given moral law is therefore superfluous and/or only epochal. We would like to suggest that neither of the above extreme responses are necessary. We believe that an alternative hypothesis needs to be developed proposing that God's laws of nature apply to both humans as well as animals, and that organisms were created with behaviors as well as morphologies that have since undergone generations of change driven by mutations, recombination and shaped by natural selection. As a result, part of man's character reflects generations of natural selection which has emphasized the selfish side of our nature. However, we accept by faith (and by reasoning which is at least logical, even though not scientifically testable) that man is not totally biologically destined but has a measure of free will —

a free will which allows him to seek the ability from God to act in ways that are truly altruistic and not just the result of gene modification and biological determination. In other words, we agree that there is a genetic process which has modified the behavior of humans and of other animals in the post-creation sinful world, and perhaps sociobiology theory correctly describes at least part of that process. Our view differs from current evolutionary thinking in an important respect. We do not believe that the data require us to accept the sociobiological assumption that all living organisms and their behaviors *originated* by that same process. The basic process of kin selection and its effect on inclusive fitness has operated within both humans and the other groups of animals, but does not require that higher taxa of animals or the behavior of the animals in those groups have evolved from common ancestors.

The application of sociobiology theory as a research tool for studying human behavior must be done with great care, as human behavior is the result of such a complex blend of inherited traits and cultural influences (learning). Hypotheses that explain any given human behavior as resulting from kin selection should be rigorously tested against alternative hypotheses incorporating the influence of learning on that particular behavior. As long as the above-mentioned cautions are applied, to guard against simplistic conclusions, sociobiology theory can be a research tool to assist in illuminating the behavior of both humans and other animals.

When we are traveling down a road and come to a fork in the road, it often is not easy to tell which fork to take without a road map. Both forks may look similar and seem to be going through similar terrain. In order to make an intelligent choice, we need to view all the information available (both scientific and non-scientific) to us and to understand as clearly as possible where each road will eventually take us.

As Christians approach a philosophical fork in the road where they must decide whether the creation of man really happened or whether man originated exclusively through an evolutionary process, it may not at first look like a critical choice. In order to fully evaluate the choice, we must not ignore where the road takes us. The development of sociobiology has helped to clarify the ultimate implications of naturalistic evolution theory to the concept of man and morality. If man really was only the product of evolution, then there would be no genuine basis for defining moral behavior; any behavior would be only a matter of evolutionary strategy. Morality born out of an evolutionary ethic is self-interested at best and may only be correct for a given ecological situation,

environment, or reproductive system at a specific time in history. Sociobiology proposes to replace all of Christianity's values and beliefs with an alternative philosophical system — a system that is built on Darwinian fitness, as measured by reproductive success. This system produces ethics which deny the existence of any true altruism or any absolute moral principles. Morality would therefore presume selfishness to be normative and reproductive interests to be the glue that holds society together.

We hope that students of the Scriptures will not feel the necessity to reject all of sociobiology or the Scripture. In an age when society is searching for the moral strength to handle the crisis of cultural and ethical ruin, we believe civilization will be benefited by considering the belief that the Bible presents standards that are moral absolutes. Now more than ever before when mankind is searching for ways to replant the seeds of morality back into society, it is incumbent upon Christians to develop ways to integrate truths that are revealed from all sources of revelation, biblical as well as scientific.

Ultimately the test case for the belief that God is the giver of all moral laws will be in the evidence that comes from lives of individuals who through the power of God are able to live in truly unselfish ways — ways that are freed from negative environmental input and years of genetic mutational load.

LITERATURE CITED

Alexander RD. 1987. The biology of moral systems. NY: Aldyne de Gruyter. 301 p.

Anderson D. 1982. Sex machines. Science Digest 90(4):74-77, 96.

Barash D. 1979. The whisperings within. NY: Penguin Books. 274 p.

Bellis MA, Baker RR. 1990. Do females promote sperm competition? Data for humans. Animal Behaviour 40:997-999.

Bentley DR, Hoy RR. 1972. Genetic control of the neuronal network generating cricket (*Teleogryllus gryllus*) song patterns. Animal Behaviour 20:478-492.

Berthold P, Querner U. 1981. Genetic basis of migratory behavior in European Warblers. Science 212:77-79.

Bertram BCR. 1975. Social factors influencing reproduction in wild lions. Journal of Zoology (London) 177:463-482.

Brandes C. 1991. Genetic differences in learning behavior in honeybees (*Apis mellifera capensis*). Behavior Genetics 21:271-294.

Drickamer LC, Vessey SH. 1992. Animal behavior. 3rd ed. Dubuque, IA: Wm. C. Brown Publishers. 479 p.

Ewer RF. 1968. Ethology of mammals. London: Elek Science. 418 p.

Fisher A. 1991. A new synthesis comes of age. Mosaic (NSF) 22(1):1-17.

Hirsch J, McGuire TR, editors. 1982. Benchmark papers in behavior, Vol. 16. Stroudsburg, PA: Hutchinson Ross Publishing Co. 392 p.

Holmes WG, Sherman PW. 1983. Kin recognition in animals. American Scientist 71(1):46-55.

Krebs JR, Davies NB. 1987. An introduction to behavioural ecology. 2nd ed. Sunderland, MA: Sinauer Associates. 389 p.

Kyriacou CP. 1990. The molecular ethology of the *period* gene in *Drosophila*. Behavior Genetics 20:191-211.

Marler PR, Hamilton (III) WJ. 1967. Mechanisms of animal behavior. NY: John Wiley and Sons. 771 p.

Maynard Smith J, Price GR. 1973. The logic of animal conflict. Nature 246:15-18.

Nalley R, Wilson EO, Batten M, Wilder R, Solomon N, Koromvokis L, Newton HP, Trivers RL. 1982. Sociobiology: a new view of human nature. Science Digest 90(7):61-69.

Packer C. 1977. Reciprocal altruism in olive baboons. Nature 265:441-443.

Plomin R, DeFries JC, McClearn GE. 1990. Behavioral genetics: a primer. 2nd ed. NY: W. H. Freeman and Co. 455 p.

Provost E. 1991. Nonnestmate kin recognition in the ant *Leptothorax lichtensteini*: evidence that genetic factors regulate colony recognition. Behavior Genetics 21:151-167.

Ricker JP, Hirsch J. 1988. Genetic changes occurring over 500 generations in lines of *Drosophila melanogaster* selected divergently for geotaxis. Behavior Genetics 18:13-25.

Rothrock PE, Rothrock ME. 1987. Christianity and E. O. Wilson's mythology of scientific materialism. Perspectives on Science and Christian Faith 39(2):87-93.

Roubertoux PL, Carlier M. 1988. Differences between CBA/H and NZB mice on intermale aggression. II. Maternal effects. Behavior Genetics 18:175-184.

Sherman PW. 1977. Nepotism and the evolution of alarm calls. Science 197:1246-1253.

Snell GD. 1988. Search for a rational ethic. NY: Springer-Verlag. 317 p.

Trivers RL. 1971. The evolution of reciprocal altruism. Quarterly Review of Biology 46:35-57.

Trivers RL, Hare H. 1976. Haplodiploidy and the evolution of the social insects. Science 191:249-263.

Wallace RA. 1973. The ecology and evolution of animal behavior. Pacific Palisades, CA: Goodyear Publishing Co. 348 p.

West-Eberhard MJ. 1975. The evolution of social behavior by kin selection. Quarterly Review of Biology 50:1-33.

Wilson EO. 1975. Sociobiology: the new synthesis. Cambridge, MA: Belknap Press of Harvard University Press. x + 697 p.

Wilson EO. 1978. On human nature. Cambridge, MA: Belknap Press of Harvard University Press. xii + 260 p.

Wilson EO. 1980a. Sociobiology. Abridged ed. Cambridge, MA: Belknap Press of Harvard University Press. 366 p.

Wilson EO. 1980b. The relation of science to theology. Zygon 15:425-434.

ANNOTATIONS FROM THE LITERATURE

ANTARCTIC PERMIAN FORESTS AND GLACIATION?

Taylor EL, Taylor TN, Cuneo NR. 1992. The present is not the key to the past: a polar forest from the Permian of Antarctica. Science 257:1675-1677.

Summary. Fifteen upright fossil stumps have been found on a mountain in the central Transantarctic Mountains at a latitude of about 84º South. Ranging from 8-18 cm in diameter, these stumps are associated with *Glossopteris* leaves and rooting structures. Distinct growth rings are preserved in the wood, but no frost rings were seen. Mean ring width was 4.5 mm, indicating rapid growth. The absence of frost rings and the large size of some of the growth rings suggest the trees grew in a warm climate, which is difficult to reconcile with the estimated Upper Permian paleolatitude for the area of 80º- 85º South.

CREATION-EVOLUTION DEBATE

Dodson EO, Howe GF. 1990. Creation or evolution: correspondence on the current controversy. Ottawa, Canada: University of Ottawa Press.

Summary. This book is a collection of letters exchanged between two biologists, one an ardent biblical creationist and the other a devout theistic evolutionist. Dodson, the theistic evolutionist, is a Roman Catholic, while Howe, the young-earth creationist, is a Baptist. Written between 1980 and 1985, the letters include both scientific and religious issues. Both writers are firm in their convictions and are certain the other is deeply in error, yet they are able to debate the issues in a generally friendly manner. One receives the impression that, at least part of the time, they rather enjoyed the opportunity to match wits with each other. Howe seems more aggressive than Dodson, and at times more aggressive than necessary, but this may not be unusual for a person holding a minority position.

Comment. The letters are interesting from a sociological standpoint, but the scientific and religious arguments could not be thoroughly explored in a series of short letters. The book should be useful in

challenging the stereotypes of creationists as untrained in science and evolutionists as irreligious.

GENETICS

Gesteland RF, Weiss RB, Atkins JF. 1992. Recoding: reprogrammed genetic decoding. Science 257:1640-1641.

Summary. Some messenger RNA (mRNA) sequences contain a set of instructions which specify an alteration in the way the genetic code is read. The authors propose the term "recoding" for this phenomenon. One kind of recoding is a shift in the reading frame. An example of frameshift recoding is in the production of a protein, release factor 2, needed for termination of translation in *E. coli*. The mRNA contains a stimulator sequence which can cause a +1 frameshift after codon 25, thus avoiding codon 26, which is a stop codon. In another case, 50 nucleotides are skipped in reading the mRNA for bacteriophage T4 gene 60. A second type of recoding is a change in the meaning of codons. For example, the codon UGA is normally a stop codon, but may be read as the amino acid selenocysteine if certain stimulator sequences are present in the mRNA.

Comment. Recoding has been discovered in viruses, bacteria, yeast, and animals. The authors believe that recoding may be universal and governed by diverse rules as yet undiscovered. As our understanding of genetics increases, the process is seen to be increasingly complex.

Jablonka E, Lachmann M, Lambs MJ. 1992. Evidence, mechanisms and models for the inheritance of acquired characters. Journal of Theoretical Biology 158:245-268.

Summary. Evidence is presented that certain changes in organisms may be transmitted through several generations of offspring even when no change in DNA sequence has occurred. An example is the degree of methylation of DNA. The addition of methyl groups to cytosine in a DNA sequence generally causes the DNA sequence to become inactive. During DNA replication, the pattern of methylation is preserved in the DNA copies. Thus the gene will also be inactive in the new cell. In unicellular organisms, the new individual will inherit the methylation pattern, and its gene will be inactive, despite the lack of change in DNA sequence. A similar argument would apply to genes that have been turned on by removal of the methyl group. Inheritance of the

condition of a gene rather than the sequence of the gene can be attributed to the presence of epigenetic inheritance systems (EIS).

EISs may be based on chromatin marking, such as methylation, by positive feedback regulatory loops, or, in a few cases, by structural inheritance. Positive feedback regulatory loops occur when a protein product stimulates further production of the protein. If the protein is transmitted to the daughter cell, the daughter cell will continue to produce the protein. Such inheritance does not depend on the sequence of the DNA, but on the presence of the regulatory protein. Structural inheritance occurs when a cellular structure is used as a template for constructing the daughter cell.

EISs seem more common in unicellular organisms and in plants than in animals. This is believed to be a result of the early separation of the germ-line during development in animals. Heritable epigenetic variations have been called "epimutations," which are believed to be considerably more frequent than DNA sequence mutations. Many inherited changes that are now thought to be caused by DNA mutations may actually be caused by epimutations.

Zouros E, Freeman KR, Ball AO, Pogson GH. 1992. Direct evidence for extensive paternal mitochondrial DNA inheritance in the marine mussel *Mytilus*. Nature 359:412-414.

Summary. Mitochondrial DNA (mtDNA) has been thought to be inherited only through females. Recently, some exceptions have been found to this rule, and this paper reports another such exception. Paternal mtDNA in *Mytilus* molluscs was estimated to be inherited at a rate of about 10%, which is a much higher rate than found in either mice or *Drosophila*.

Lewan MD. 1992. Role of water in petroleum formation. U.S. Geological Survey Circular 1074:46.

Summary. Laboratory experiments show that the presence of water is an important factor in the generation of petroleum. Two reactions are involved in petroleum formation. In the first reaction, insoluble kerogen is decomposed to soluble bitumen. This is accomplished by cleavage of weak noncovalent bonds in the kerogen, and does not require the presence of water. The second step is the decomposition of bitumen to oil. This step involves cleavage of covalent bonds, and requires the presence of water. The resulting oil is immiscible in the water-bitumen mixture and separates out. The production of oil is accompanied by an

increase in volume, causing a decrease in density and expulsion of the oil from the source rock.

Thompson AB. 1992. Water in the Earth's upper mantle. Nature 358:295-302.

Summary. Water is present in all magmas and mantle rocks. The presence of water lowers the melting point of rocks significantly. For example, under certain conditions of pressure and in the presence of excess water, the melting point of dry peridotite solidus is reduced from 1800° C to about 1100° C. The author suggests that as hot rock is cooled during subduction, water is released into the overlying mantle, reducing the melting temperature of the mantle. The author concludes that water diffused in molten rock has a much greater metamorphic effect than it does as an associated fluid.

Comment. It would be interesting to know what effect the lowered melting temperature of water-containing rocks would have on calculations of magma-cooling rates and the heat generated by plate movements.

IMPACT CATASTROPHES

Claeys P, Casier J-G, Margolis SV. 1992. Microtektites and mass extinctions: evidence for a Late Devonian asteroid impact. Science 257:1102-1104.

Summary. One of the largest marine mass extinctions in the geologic record occurred in the Upper Devonian, at the Frasnian-Famennian (F-F) boundary. At least 70% of all species and about 50% of all genera are not found in stratigraphically higher layers. This paper reports the discovery of microtektite-like spherules associated with the F-F boundary in Belgium. These spherules suggest an extraterrestrial impact was associated with the F-F mass extinction. Upper Devonian impact craters include the Siljan Ring in Sweden and Charlevoix Crater in Quebec. The Siljan Ring is the largest known impact structure in Europe, with a diameter of 52 km. Charlevoix Crater has a diameter of 46 km, and would be near Belgium in tectonic plate reconstructions for the Upper Devonian.

Poag CW, Powars DS, Poppe LJ, Mixon RB, Edwards LE, Folger DW, Bruce S. 1992. Deep Sea Drilling Project site 612 bolide event: new evidence of a late Eocene impact-wave deposit and a possible impact site, U.S. east coast. Geology 20:771-774.

Summary. A boulder bed 60 m or more in thickness covers over 15,000 km^2 in an area including Chesapeake Bay. Trace quantities of

tektite glass and shocked quartz are associated with the boulder bed, indicating association with an extraterrestrial impact. The deposit is interpreted as due to a tsunami, with a wave height of as much as 500-1000 m. The size of the boulders suggests a nearby impact site. A possible impact crater has been located on the outer continental shelf some 200 km from the boulder bed. About 15×25 km in size, the crater could have been produced by a bolide about 1 km in diameter.

MEGA-VOLCANISM IN THE ORDOVICIAN

Huff WD, Bergstrom SM, Kolata DR. 1992. Gigantic Ordovician volcanic ash fall in North America and Europe: biological, tectonomagmatic, and event-stratigraphic significance. Geology 20:875-878.

Summary. Volcanic ash beds in North America and Europe have been identified as probably coming from the same volcanic eruption. Correlation is based on several lines of evidence, including trace-element analysis. The ash is present in the form of K-bentonite beds which reach a thickness of 1-2 m and cover millions of square miles in eastern North America and northwestern Europe. The eruption produced at least 340 km^3, and possibly more than 1100 km^3, of ash, and may have been the largest such event recorded in the geologic record. The amount of volcanic dust is calculated to have been of the same order of magnitude as that expected from the postulated extraterrestrial event at the Cretaceous-Tertiary boundary event. The lack of any major extinction associated with this Ordovician volcanic event casts doubt on the interpretation that atmospheric dust was a major cause of extinction at the Cretaceous-Tertiary boundary.

MOLECULAR PALEONTOLOGY

Cooper A, Mourer-Chauvire C, Chambers GK, von Haeseler A, Wilson AC, Paabo S. 1992. Independent origins of New Zealand moas and kiwis. Proceedings of the National Academy of Sciences (USA) 89:8741-8744.

Summary. Moas were giant flightless birds that lived in New Zealand during prehistoric times. They may have been extirpated by human settlers. Subfossil moa eggs, bones and skin have been found. Kiwis are also flightless birds, still surviving in New Zealand. The two groups have been thought to be each others' closest relatives, based on morphological similarity and similar distributions.

Recent developments in molecular paleontology have made it possible to analyze molecular sequences from fossil tissues. The authors used a sequence of about 400 base pairs from the mitochondrial 12S rRNA gene. Comparisons were made for four species of moa, three species of kiwis, the Australian emu and cassowary, the African ostrich, two species of South American rheas, and one species of South American tinamou. Results showed the four species of moas in one group, not closely similar to any of the other groups. The kiwis formed another distinct group, most similar to the emu and cassowary. The rheas and the tinamou were the most isolated groups.

The large flightless birds (known as ratites) are restricted to the southern continents, although ostrich-like fossils are known from Europe and Asia. This has sometimes been explained as the result of splitting of the Gondwanan land mass. However, neither the molecular data, reported in this paper, nor the fossil data, support such a scenario. The present distribution of ratites should not be used as evidence for the validity of plate tectonic reconstructions.

DeSalle R, Gatesy J, Wheeler W, Grimaldi D. 1992. DNA sequences from a fossil termite in Oligo-Miocene amber and their phylogenetic implications. Science 257:1933-1936.

Summary. Termites of the genus *Mastotermes* are known as fossils from Mexico and the West Indies, but today live only in northern Australia. The family contains no other living genera, but extinct genera are known as fossils from Brazil, Tennessee and Europe. The authors have recovered DNA from a fossil *Mastotermes* from Dominican amber supposedly 25 million years old. The DNA sequences recovered included over 200 base pairs from the nuclear 18S rRNA gene, and nearly 100 base pairs from the mitochondrial 16S rRNA gene. Comparison with DNA from the living species of *Mastotermes* showed 9 differences in the 16S DNA and 3 differences in the 18S DNA. The primitive appearance of these termites had led to suggestions they might be indicators of an evolutionary relationship between termites and cockroaches. This hypothesis was not supported by the DNA sequence comparisons made.

Comment. The recovery of intact DNA sequences from fossils believed to be 25 million years old is remarkable, since laboratory experiments indicate DNA decomposes rather quickly. The explanation for the survival of the DNA may be that oxygen was excluded by the

amber, and that the material may be much younger than generally thought.

Janczewski DN, Yuhki N, Gilbert DA, Jefferson GT, O'Brien SJ. 1992. Molecular phylogenetic inference from saber-toothed cat fossils of Rancho La Brea. Proceedings of the National Academy of Sciences (USA) 89:9769-9773.

Summary. Saber-toothed cats are the second most common fossil in the asphalt deposits of Rancho La Brea in southern California. DNA was extracted from bones of the saber-toothed cat and amplified using the PCR method. Two sequences were obtained, part of the mitochondrial 12S ribosomal RNA sequence, and a portion of the feline MHC class I gene. Sequences were compared with those from several orders of mammals, including various species of cats. Results indicate a close similarity of saber-toothed cats to living cat species, particularly the large cats.

Muyzer G, Sandberg P, Knapen MHJ, Vermeer C, Collins M, Westbroek P. 1992. Preservation of the bone protein osteocalcin in dinosaurs. Geology 20:871-874.

Summary. Osteocalcin is a protein of about 50 amino acids, found in bone. Immunological assays were used to test for the presence of osteocalcin in various fossil materials. Strongly positive tests were obtained for several modern and Pleistocene vertebrates. Positive tests were also obtained for four Cretaceous and one Upper Jurassic dinosaur. Two dinosaur fossils and three control materials tested negative.

Comment. The authors attribute the unexpected preservation of proteins in fossil dinosaurs to burial conditions, especially a limited maximum temperature. No doubt burial conditions are important, but one wonders whether the fossil may actually be much younger than conventional interpretations would permit.

MOLECULES VS MORPHOLOGY

Sturmbauer C, Meyer A. 1992. Genetic divergence, speciation and morphological stasis in a lineage of African cichlid fishes. Nature 358:578-581.

Summary. Lakes Victoria, Malawi and Tanganyika are noted for their diversity of cichlid fishes, of which there are hundreds of species. The main lineages of Lake Tanganyika cichlids are highly diversified

morphologically. The genus *Tropheus* consists of six species endemic to Lake Tanganyika. These species differ primarily in coloration, and are quite similar morphologically. Despite their morphological uniformity, the extent of variation of mitochondrial DNA sequences is greater among the six species of *Tropheus* than among the entire species flocks of either Lake Victoria or Lake Malawi. The basis for the disparity between morphological and genetic diversity is unknown. One possible explanation might be that past fluctuations in lake level have isolated parts of the lake, resulting in genetic divergence. It is not clear why morphological divergence would not have occurred concurrently.

ORIGIN OF LIFE

Weber AL. 1992. Prebiotic sugar synthesis: hexose and hydroxy acid synthesis from glyceraldehyde catalyzed by iron (III) hydroxide oxide. Journal of Molecular Evolution 36:1-6.

Summary. Several sugars can be produced from glyceraldehyde in a reaction catalyzed by iron (III) hydroxide oxide. Among the products were sorbose, fructose, psicose, tagatose, dendroketose, and about ten other substances, some unidentified. Sugars are an important component of living cells, and their production is an essential part of any model that attempts to provide a naturalistic explanation for the origin of life. This experiment adds to the evidence that such an explanation is not likely to be forthcoming in the foreseeable future.

Comment. Although the reaction did produce sugars, it did not produce ribose. Ribose production is considered to be essential in any explanation for the origin of life. Even if ribose had been produced in the reaction, serious problems would remain. These include the problem of chirality, chemical interference from other products of the reaction, and the fact that most catalysts eventually decompose the sugars to acids, alcohols and hydroxyacids. These problems, together with the fact that ribose was not produced, continue to be serious difficulties for the theory of a naturalistic origin of life.

PALEOBOTANY

Crepet WL, Nixon KC, Friis EM, Freudenstein JV. 1992. Oldest fossil flowers of hamamelidaceous affinity, from the Late Cretaceous of New Jersey. Proceedings of the National Academy of Sciences (USA) 89:8986-8989.

Summary. Well-preserved, apetalous fossil flowers have been discovered in a Cretaceous deposit in New Jersey. The flowers have a unique combination of characteristics now found in separate genera of two families: Platanaceae and Hamamelidaceae. The fossils are considered to be an extinct taxon of Hamamelidaceae because they possess certain derived characteristics of that family. The mosaic nature of the fossil flowers will likely cause changes in the evolutionary interpretation of relationships among hamamelidaceous plants.

The presence in the fossils of staminoidal nectaries that are somewhat petal-like is considered to be of considerable evolutionary significance. The closest relatives of the Hamamelidaceae lack petals, whereas many modern genera have petals. It is proposed that the petal-like staminoidal nectaries in the fossil represent an evolutionary transition in the development of petals in modern taxa. This hypothesis is complicated by the fact that fully formed petals are known from an older fossil of a sister group, the Rosidae. Accordingly, petals in the two groups must have separate and independent origins.

PALEONTOLOGY

Bengtson S, Yue Z. 1992. Predatorial borings in Late Precambrian mineralized exoskeletons. Science 257:367-369.

Summary. *Cloudina* is a fossil of a tube-dwelling organism found in upper Precambrian sediments in several parts of the world. Stratigraphically, *Cloudina* is the lowest fossil known to have a mineralized skeleton. Examination of more than 500 tubes from a deposit in China showed that about 2.7% of the tubes had borings that appear to be those of a predator. This shows that predators were present when these Precambrian fossils were living. The evidence from Precambrian fossils of predator-prey relationships indicates a greater diversity and more complex relationships among Precambrian organisms than previously understood.

Chafetz HS, Buczynski C. 1992. Bacterially induced lithification of microbial mats. Palaios 7:277-293.

Summary. Stromatolites are lithified structures believed formed from algal mats by the trapping of detrital carbonate particles. More recently, it has been discovered that some of the carbonate is precipitated by micro-organisms, thought to be principally cyanobacteria. This paper reports that carbonate precipitation occurred on cyanobacterial filaments only in the presence of live bacteria. It appears, therefore, that the precipitation is actually accomplished by bacterial decay. Precipitation began within a few hours after death. Carbonate precipitation by bacteria occurs after burial of the cyanobacterial mat.

Foote M. 1992. Paleozoic record of morphological diversity in blastozoan echinoderms. Proceedings of the National Academy of Sciences (USA) 89:7325-7329.

Summary. The "Cambrian explosion" is well-known for the sudden appearance of fossils with a great diversity of body types. Similar patterns of great initial diversity may be seen in some taxonomic groups in other parts of the geologic column. In this study, the author examines the fossil record of blastozoans, an extinct group of echinoderms. Results show that the ratio of morphological diversity to taxonomic diversity is greatest in Cambrian deposits. Morphological diversity itself is greatest in Ordovician deposits.

Comment. This trend is contrary to the intuitive evolutionary expectation of a single ancestral type giving rise to an increasing diversity over time. The standard explanation is an evolutionary radiation into previously unoccupied ecospace. However, the repeated pattern of sudden appearance of diversity seems consistent with expectations based on a catastrophic model of deposition.

Han T-M, Runnegar B. 1992. Megascopic eukaryotic algae from the 2.1-billion-year-old Negaunee iron-formation, Michigan. Science 257:232-235.

Summary. *Grypania spiralis* is a spirally coiled Precambrian fossil found in Montana, China and India. It is believed to have been a photosynthetic alga. Fossils similar to *Grypania* have been found recently in Michigan. These fossils are believed to be 2.1 billion years old, which is believed to be as much as a billion years older than previously known *Grypania* fossils. Since *Grypania* is believed to be a eukaryote, the purported evolutionary origin of eukaryotes is pushed back to before 2.1 billion years ago.

Kerr RA. 1991. Old bones aren't so bad after all. Science 242:32-33.

Summary. The completeness of the fossil record has been much debated. Two recent studies have addressed this problem for marine molluscs. In one survey, 16 studies of live/dead associations were reviewed. Of living species, 83%-95% were found dead at the same site. In short-term studies, only 33%-54% of the dead species were found living, but this figure rose to 75% over longer study periods. One conclusion was that a study should last as long as the longest-lived species. Rare shells and small shells are least reliable. Another study (Valentine 1989) in Baja California ascertained that 77% of living species are found as fossils. Increased searching might bring the total to 85%. These two studies suggest that the fossil record for molluscs might be more complete than many have thought.

Lepper BT, et al. 1991. Intestinal contents of a Late Pleistocene mastodont from midcontinental North America. Quaternary Research 36:120-125.

Summary. A nearly complete, well-preserved skeleton of an American mastodont was recovered in a peat deposit being excavated for a golf-course pond in Licking County, Ohio. A mass of plant material was found in the stomach position of the fossil, and was analyzed for bacteria. Living bacteria were recovered, of the species *Enterobacter cloacae*, a common species of intestinal bacteria. Soil samples from near the bones failed to produce any bacteria of that species. This is the first time living bacteria have been recovered from Late Pleistocene large mammals.

RAPID SPECIATION

Weinberg JR, Starczak VR, Jorg D. 1992. Evidence for rapid speciation following a founder event in the laboratory. Evolution 46:1214-1220.

Summary. *Nereis acuminata* is a marine polychaete annelid worm often used in studies of environmental pollution. The species has a wide distribution, including the coastlines of North America, Europe, Africa and the western Pacific. The species also exists in a laboratory culture started in 1964 from 5 or 6 individuals. The population of the culture expanded to several thousand individuals by 1986. At that time, four pairs of worms were transferred to Woods Hole Oceanographic Institution, and a new subculture established. This subculture also expanded to several thousand individuals. Thus, this laboratory subculture had gone through two significant bottlenecks

This paper reports the results of experiments designed to test whether the lab subculture was still interfertile with the natural parental species. No population of these worms was found at the site of the original collection for the laboratory culture. However, two populations were found located 11 and 37 km from the parental site. These populations were tested for reproductive isolation with the laboratory population. Both populations interbred successfully with each other, but neither population produced viable offspring when crossed with the laboratory culture. This strongly suggests that reproductive isolation was produced in the laboratory culture over a period of less than 30 years. The authors propose that divergence in sex pheromones may have contributed to the apparent speciation. The founder effect may have played an important role in the process, but this has not been tested.

SOUTHERN HEMISPHERE BIOGEOGRAPHY

Hill RS. 1992. *Nothofagus*: evolution from a southern perspective. Trends in Ecology and Evolution 7:190-194.

Summary. *Nothofagus*, the southern beech tree, is restricted to the southern hemisphere, principally in Australia, New Zealand and South America, with fossils also from Antarctica. The distribution of the genus has been interpreted as supporting the concept of the union of the land masses in Pangaea. *Nothofagus* fruits are not adapted for survival in sea water, and the conventional wisdom is that the presence of *Nothofagus* on the southern continents is strong evidence of a former land connection. However, some evidence suggests that overwater dispersal across the Tasman Sea may have occurred. All four *Nothofagus* pollen types are found in Australia in sediments believed much older than any *Nothofagus* fossils in New Zealand. The New Zealand fossils are all Cenozoic, deposited after the isolation of New Zealand. Such overwater dispersal weakens the significance of *Nothofagus* fossils as a key to understanding southern biogeography.

VERTEBRATE PALEONTOLOGY

Begun DR. 1992. Miocene fossil hominids and the chimp-human clade. Science 257:1929-1933.

Summary. Some fossils from Hungary have been re-classified in the genus *Dryopithecus*, resulting in significant changes in evolutionary interpretation of human and ape relationships. The fossils were formerly

classified in the genus *Rudapithecus*. The reclassification permits analysis of additional characters of the genus *Dryopithecus* and their comparison with other hominoids. *Dryopithecus* and *Gorilla* share several traits now interpreted as being primitive. Begun concludes that several characteristics shared by *Australopithecus* and *Pan* (chimps) are actually derived, rather than primitive as had been thought. The result of this reinterpretation is that chimpanzees are thought to be more closely related to humans than to gorillas. Although this relationship has been supported by molecular studies, most morphologists have placed chimpanzees closer to gorillas, based on similarities such as knuckle-walking.

Comment. An alternative interpretation is presented in Nature 359:676-677. It proposes that the fossil ape, *Graecopithecus*, is closer than *Dryopithecus* to the ancestry of hominines. *Graecopithecus* is said to be especially similar to the gorilla, but is dated at 8-10 million years old. In evolutionary terms, this implies a date of at least 9 million years for the divergence of gorillas and humans. This presents a conflict with molecular evolution, since molecular comparisons between the two species are interpreted as indicating a much more recent time for divergence.

Ducrocq S, Buffetaut E, Buffetaut-Tong H, Jaeger J-J, Jongkanjanasoontorn Y, Suteethorn V. 1992. First fossil flying lemur: a dermopteran from the Late Eocene of Thailand. Palaeontology 35:373-380.

Summary. Flying lemurs, also known as colugos, are gliding mammals presently found only in Southeast Asia. They have been linked to various groups of fossils, most often the extinct Plagiomenidae, but more recently the extinct Paromomyidae. The new fossil is sufficiently similar to living flying lemurs to be classified in the same family. Fossils previously identified as dermopterans are now reinterpreted as not belonging to that group. The new fossil is said to be the only valid record of a fossil dermopteran.

Ducrocq S, Buffetaut E, Buffetaut-Tong H, Jaeger J-J, Jongkanjanasoontorn Y, Suteethorn V. 1992. First fossil marsupial from South Asia. Journal of Vertebrate Paleontology 12:395-399.

Summary. A single tooth discovered in Middle Miocene sediments from Thailand has been identified as belonging to a marsupial. This is the first record of marsupials from southern Asia. The tooth has been referred to a new genus in the opossum family, Didelphidae. Fossils of

this family have been found throughout most of the world, except Australia. The taxonomic contrast between this didelphid fossil and Australian Miocene marsupial fossils seems to weaken the hypothesis that marsupials reached Australia via southern Asia.

Elzanowski A, Wellnhofer P. 1992. A new link between theropods and birds from the Cretaceous of Mongolia. Nature 359:821-823.

Summary. A juvenile skull from Mongolia shares some features with theropod dinosaurs and some with primitive birds such as *Archaeopteryx* and *Hesperornis*. Similarities with *Archaeopteryx* include the broad palatal shelf and the conical maxillary teeth which lack serrations and carinae. Similarities with *Hesperornis* include the broad palatal shelf and the configurations of some sinuses, which differ from those in theropods. Similarities with theropods include the tetraradiate palatine.

This upper Cretaceous specimen is much too "late" to be ancestral to *Archaeopteryx*. The authors suggest it may be the closest yet found to the ancestry of birds.

Fox RC, Youzwyshyn GP, Krause DW. 1992. Post-Jurassic mammal-like reptile from the Palaeocene. Nature 358:233-235.

Summary. Discovery of a fossil lower jaw with teeth has resulted in an argument over its interpretation. The fossil was found in the Paleocene Paskapoo Formation in Alberta, Canada. The discoverers interpret the fossil as a cynodont, a group of mammal-like reptiles not previously found in sediments above the Middle Jurassic. In conventional geologic terms, this implies a time gap of some 100 million years, during which no mammal-like reptiles were preserved as fossils. This interpretation of the fossil has been attacked by Sues (Nature 359:278), who argues that the fossil's characteristics do not show it to be a cynodont. Sues points out that some of the fossil's characteristics are not shared with any known cynodont, and implies that it may actually be a mammal fossil. Hecht (New Scientist 135:18) quotes one paleontologist as saying he would have no problem calling the fossil a mammal-like reptile if it were found in Triassic sediments. Another paleontologist is quoted by Hecht as stating he would have suspected it was a dinosaur if it were found in Cretaceous sediments. It is hoped that additional material can be discovered that will clarify the fossil's identity.

Norell MA, Novacek MJ. 1992. The fossil record and evolution: comparing cladistic and paleontologic evidence for vertebrate history. Science 255:1690-1693.

Summary. Phylogenetic hypotheses based on the fossil sequence should be independent of those based on cladistic methods. This paper compares the two methods for 24 groups of vertebrates. The correlation between age rank and clade rank was statistically significant for 18 of the groups. Correlations for the other six groups were not significant. This result tends to support the contention that the supposed direction of evolution is frequently, but not always, recorded in the fossil record. However, cladistics is heavily dependent on the direction of character polarity, which is often determined from the fossil record, making it difficult to accept the two methods as truly independent.

Sereno PC, Novas FE. 1992. The complete skull and skeleton of an early dinosaur. Science 248:1137-1140.

Summary. Dinosaurs are commonly believed to form a natural group with a common ancestry. This conclusion is supported with an extensive list of shared derived characteristics (synapomorphies). The discovery of a complete dinosaur skeleton from the Upper Triassic of Argentina provides additional evidence bearing on the question of dinosaur relationships. The new material is of the genus *Herrerasaurus*, once classified as a theropod, but more recently considered to belong to a group ancestral to the other dinosaurs. Cladistic analysis had suggested 59 characteristics linking dinosaurs as a natural group. Including the new fossil material in the analysis reduced the number of linking characteristics to eight from the original list, and added five others. The authors conclude that *Herrerasaurus* is a theropod. This implies that both saurischians and ornithischians must have existed before the Upper Triassic sediments were deposited. Another implication is that sauropod dinosaurs must also have existed during Upper Triassic deposition, although fossil sauropods are not known in Triassic sediments.

Comment. This discovery illustrates how sensitive cladistic analysis is to addition or omission of taxa. It also suggests another example of diversity at first appearance in the fossil record.

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.

AN AGE-OLD QUESTION

THE AGE OF THE EARTH. 1991. G. Brent Dalrymple. Stanford, CA: Standord University Press. 474 p. Cloth, $49.50.

Reviewed by R. H. Brown, Yucaipa, California

There has been a long-standing need for a convenient compilation of the radiometric data from which conclusions have been drawn concerning the length of time planet Earth and other components of the Solar System have been in existence. *The Age of the Earth* meets this need more than adequately. The author is Research Geologist at the U.S. Geological Survey, Menlo Park, California, and is preeminently qualified to give a comprehensive, authoritative, and readable treatment of the topics he addresses. In his Preface he states that the book was "written for people with some modest background in science, ... [to be] useful and informative to those without a deep knowledge of geology or physics." The book provides valuable resource material for individuals who make a professional-level witness for a creationist viewpoint, although the author's analysis of data is from a purely secular, uniformitarian approach that dismisses concepts of supernatural and revelation as purely human and non-authoritative.

Technical terms and concepts are explained within the text so that the treatment is understandable to the non-specialist. A 14-page glossary provides additional assistance. The treatment is well-illustrated by 15 half-tones, 14 maps, and 98 high-quality line drawings. Many readers will not be interested in the extensive mineralogical and geological detail in some sections of Dr. Dalrymple's treatment, but the persistent reader will be well rewarded. Citations to the original supporting scientific literature are given within the text. Readers who wish to investigate any topic more deeply have 37 pages of references for these citations. Each technical chapter concludes with a summary, and the final chapter is a summary of the entire book.

Chapter Two reviews the estimates for the age of planet Earth that were made before the radiometric era (before circa 1950), including those based on the Pentateuch. A tabulation of these estimates (Table 2.1) covers four pages.

The third chapter is a tutorial on the use of the various radiometric daughter/parent pairs for data from which age estimates may be made. These estimates cover primary age, age since a metamorphism, and ages over the range between these limits. To the evidence given for the constancy of radioisotope decay rates, I can add that provided by radiohalos (Brown 1990). I recommend this chapter to anyone who is looking for a relatively quick and easy way to become familiar with the rudiments of radioisotope dating. Toward the end of the book (Chapter 7), an entire chapter is devoted to the use of lead isotope ratios as indicators of time spans.

It is unfortunate that the author's treatment of isochrons (linear sequences of a group of associated daughter/parent isotope ratios) does not explain how these sequence plots could also be interpreted as mixing diagrams, rather than a daughter isotope accumulation plot (isochron). This possibility has been used by some apologists in efforts to discredit use of radioisotope data as an indication of real time.

If there is a non-uniform distribution of parent isotope among a group of related samples, a plot of daughter concentration against associated parent concentration (or more commonly, plot of the ratios of daughter and parent isotopes to a reference isotope) will be a straight line if the daughter concentration represents growth by radioactive decay of the parent. For a common time lapse the amount of daughter difference between any two samples will be proportional to the amount of parent difference, hence the term isochron (equal time). An identical plot can be produced by an incomplete mixture of material from two sources that had differing parent and/or daughter concentrations. Such a plot would be merely a mixing line that has no relationship to the time at which the mixing occurred. But the upper end of the line of data terminates at or points to the daughter/parent ratio which specifies a radioisotope age for one source, and the lower end terminates at or points to the daughter/parent ratio which specifies a radioisotope age for the other source. If the ratio of parent to excess of daughter above the amount of daughter specified by cosmic isotope abundance ratios is the same for each of these sources, an isochron interpretation assumes

the daughter excess accumulated since mixing, and hence specifies *time since the mixing* that produced the common suite of samples. A mixing line interpretation, however, gives the *age of the components* of the inhomogeneous mixture, but provides no indication of the time since mixing occurred.

Interpretation as a mixing line is clearly indicated if the best straight-line fit to the data points intercepts the daughter isotope axis at a point significantly different from the cosmic ratio of the daughter isotope (ratio characteristic of minerals which have no indication of having been associated with the parent element). In such cases the data set limits for the radioisotope age which characterizes each component of the mixture.

Mixing line interpretation is a valid option regardless of where the line intercepts the daughter isotope axis. In any case a mixing line interpretation provides no escape from a real time significance of radio-isotope daughter/parent ratios. Linear plots of daughter versus parent for some inhomogeneous sets of samples may be expected to represent isochron development following initial formation by mixing. Isochron development gives a counterclockwise rotation to the initial mixing line, but leaves no basis for determining how much time has elapsed since the mixing process.

The Age of the Earth makes two major contributions. One is a convenient collection of radioisotope data for the lowest rocks in the geological sequence of Earth's crust (Chapter 4), rocks from the Moon (Chapter 5), and meteorites (Chapter 6). The other major contribution is ready access to analysis of these data. Any reader will be impressed at the frequency with which the figure 4.56 billion years appears from a wide range of independent radioisotope techniques applied to a wide range of samples. How a creationist accommodates to this evidence will depend on whether he/she considers it to be a consequence of the way God has managed/maintained the Universe, or a design characteristic expressed at initial creation.

Dalrymple makes a good case for an age of about 4.5 billion years for the material of which the earth, moon, and meteorites are composed. He evidently believes that he has thoroughly discredited special creationism. His treatment in *The Age of the Earth* has made it much more difficult to plausibly explain radiometric data on the basis of a creation of the entire Solar System, or the physical matter in planet

Earth, within the last few thousand years. In my opinion, the defense of such a position is a losing battle.

However, the data presented by Dr. Dalrymple are not incompatible with a model which allows for most of the Solar System to have come into existence about 4.5 billion years ago, the creation of life on planet Earth within the last 10,000 years, and a subsequent reorganization of the planet's surface by a cataclysm in which there was water burial of a vast number of organisms.

The final technical treatment in the book (Chapter 8) completes age considerations with a summary of speculative models concerning the ages of stars and galaxies. Readers who follow details carefully should correct Table 8.5 on p. 388 to specify 1/137.88 for R of $^{235}U/^{238}U$.

In concluding this review, I should say that in my opinion it is both incorrect and inadequate to model the physical features of the universe on the basis of natural evolution from an unexplainable initial "Big Bang"; and that it is equally incorrect to ignore the evidence for physical process and change. The basic data and their implications as given in *The Age of the Earth* present no conflict with biblical testimony as long as the creation account is interpreted strictly in accord with the definitions given in Genesis 1:8-10, and if the radioisotope ages of material that encloses or overlies fossils are recognized as having no more relationship to fossil age than similar data for a modern cemetery, or a community buried by a landslide, have to the dates of the interments therein.

ACKNOWLEDGMENT

Appreciation is due for the contributions of Dr. Paul Giem in the preparation of this review.

REFERENCE

Brown RH. 1990. Radiohalo evidence regarding change in natural process rates. Creation Research Society Quarterly 27(3):100-102.

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.

THE SEARCH FOR RELATIVES

THE EARLY EVOLUTION OF METAZOA AND THE SIGNIFICANCE OF PROBLEMATIC TAXA. 1991. A.M. Simonetta and S. Conway Morris (eds.). Proceedings of an International Symposium held at the University of Camerino, Italy, 27-31 March 1989. Cambridge and NY: Cambridge University Press. 296 p. Cloth, $69.95.

Reviewed by L. J. Gibson, Geoscience Research Institute

Evolutionists have spent a great deal of effort attempting to determine the interrelationships of the invertebrate phyla. This effort has been plagued by difficulties, but the quest continues. The present book contains much of interest for those concerned with the question of invertebrate interrelationships. The book is a symposium volume containing 24 different articles ranging in length from a single paragraph on Cambrian medusiforms (Sun Weiguo) to a 56-page discussion of Paleozoic arthropods (Simonetta & Delle Cave). The latter paper contains a large number of excellent drawings of reconstructions of the animals. The book's emphasis is fossils, but a phylogeny of recent invertebrates based on ribosomal RNA sequences is included (Christen et al.).

The inclusion of different opinions gives the reader opportunity to evaluate opposing arguments and adds to the usefulness of the book. For example, Schram uses the cladistic method to propose a hypothesis of invertebrate relationships, concluding that it may not be correct, but at least is scientific. Simonetta and Delle Cave begin their discussion (p 189) with the statement that "the principles of Hennigian cladism have been falsified and can be largely discounted." Another difference of opinion concerns the relationships of the extinct conulariids. Babcock (p 133) concludes they are an independent lineage with no known rela-

tives, while Van Iten (p 145) groups them with the cnidarians (coelenterates).

Another example concerns evolutionary process. Conway Morris maintains (p 19) that microevolutionary processes are sufficient to explain invertebrate evolution, while Bergstrom (p 25) argues that invertebrate phyla arose by macroevolutionary processes.

Two papers describe the Lower Cambrian Chengjiang fauna. This is a Burgess Shale type fauna recently found in China. Chen & Erdtmann (p 57-76) summarize the fossil biota. Algae are predominant, including a green alga, *Yuknessia*, also known from the Canadian Burgess Shale. The largest group of invertebrates are the arthropods, which include at least two genera shared with the Burgess Shale. The enigmatic animal, *Anomalocaris*, is also shared with the Burgess Shale. The next largest group is the sponges, with 25 or more species known. In addition, the fauna includes medusiforms, sea anemones, priapulid worms, brachiopods, and other types. The other paper, by Hou & Bergstrom (p 179-187), discusses the Chengjiang arthropods. Bivalved arthropods are especially common. Some are tiny, and others are larger. Numerous trilobites and smaller numbers of other groups are also present. The authors comment on the surprising similarities between the Chengjiang and Burgess Shale faunas. The close similarity of the two groups is difficult to reconcile with the great difference in their supposed ages.

Several other topics are considered, such as the relationships of proturan "insects," reef-building sponges, and various groups of problematica. Bernini reports that Lower Devonian mites are so similar to modern species that they give no clue to the origins of the group. Bruton's paper on jellyfish taphonomy is particularly interesting. Using beach and laboratory experiments to study the taphonomy of jellyfish, he determined that dead jellyfish which sink to the ocean floor do not leave identifiable impressions. He concludes that this casts doubt on the interpretation of Upper Precambrian "medusoid" traces as jellyfish.

Overall, the book contains much of interest. I noted a few inconsequential typos, but the book is generally well done. Coverage is uneven, as one would expect from an edited compilation, but there is something in it for nearly anyone interested in invertebrate paleontology.

GENERAL SCIENCE NOTES

LIFE IN THE DEEP ROCKS AND THE DEEP FOSSIL RECORD

By Ariel A. Roth, Geoscience Research Institute

WHAT THIS ARTICLE IS ABOUT

It has been known for many years that microorganisms can exist in rocks several kilometers below the surface of the earth. Recently a number of reports indicate that these organisms are much more common than previously surmised and that vast regions of the underworld may be inhabited.

This new information has interesting implications for both evolutionism and creationism. From the evolution viewpoint, simple organisms, whose poorly preserved fossils are found in the older rocks, represent early stages of evolution. Could these represent not-so-old organisms that had been living in the rocks? For creation the new findings can suggest that the fossils found in these lower rocks represent life in the rocks that existed there since a recent creation. The similarity of some of the fossil forms to modern ones lends credence to this concept.

LIFE IN THE ROCKS

We are all familiar with the animals and plants on land, as well as plankton, fishes and whales of the world oceans; however, a new biological realm is coming into focus: that of life in the rocks. The rocks of the crust of the earth, especially the deeper ones, are relatively inaccessible. "Out of sight — out of mind" certainly applies here; and it is not surprising that although we have known of some life in deep rocks for decades, only recently have scientists given serious attention to this hidden biological realm.

It has long been known that organisms such as bacteria, worms and insect larvae abound in the top 1 m (3 ft) of Earth's soils. Below this level, the number of organisms decreases dramatically, but persists to great depths in surprising numbers. Microorganisms of various kinds are the only kind of life that flourishes at these depths. Examples abound.[1] Sulfur-reducing bacteria are abundant in aquifers 800-1000 m deep in

the Bachu district (former USSR). In that region bacteria are so abundant they impart a pink color to water coming from oil-well drilling. One well produced some 5000 kg (11,000 lbs, or 1400 gal) of pink water daily for 6 months.[2]

In England, iron- and sulfur-oxidizing bacteria produce a red slime found in abundance in a tin mine located in granite rock at a depth of 600 in (2000 ft).[3] A coal seam in Germany harbors about 1000 bacteria per gram of coal lying at a depth of 400 m (1300 ft). About the same concentration of bacteria was found in groundwater over 1000 m (3300 ft) below the surface, in the Madison limestone of the northwest U.S.A.[1]

Bacteria can readily grow when introduced into deep environments. Some that oxidize methane have been injected into coal layers to significantly reduce the concentration of that explosive gas in coal mines. Bacteria are also being used to enhance oil production by releasing oil from sedimentary reservoirs.[2]

Extensive studies have been conducted in South Carolina in three boreholes, with depths as great as 500 m (1600 ft). Typically 100,000 to 10,000,000 bacteria were found per gram of sediment, and over 4500 different strains were isolated. In less permeable sedimentary layers (clay) lying between aquifers the numbers of bacteria were much fewer — typically less than 1000 per gram.[4] Protozoa (one-celled animals) and fungi were also found, but in significantly lower concentrations than bacteria.[5] Protozoa and bacteria have also been found in a number of other deep subsurface sediments.[6] Surprisingly, at the South Carolina site, unicellular and filamentous live green algae that usually require light for growth were found at a number of levels in two of the boreholes down to 210 m (700 ft).[5] Their presence at these great depths was explained as possibly indicating some sort of connection to the surface, or a very long viability for these algae. Another study demonstrated the presence of viruses of the bacteriophage type at a depth of 405 m (1330 ft).[7]

Microorganisms are probably found in all sedimentary rocks,[8] and are most abundant in aquifers. They have also been discovered in granite. Thomas Gold[9] provides convincing evidence of their activity at a depth of 6000 m (20,000 ft) in an exploration oil well drilled in Sweden's Siljan impact crater (44 km, or 27 mi, diameter). Furthermore, he reports on the isolation of several strains of living bacteria found in depths greater than 4000 m (13,000 ft) at the same locality. He even suggests that the

volume of living organisms in the rocks may be comparable to that of all organisms living on the surface of the earth.[10] Considering the thickness of the rock layers, one can envision a lot of life below our feet.

The abundance of life in the rocks has rekindled interest in life on Mars. In some quarters, it is hoped that life can be found in the deep rocks of that planet. Future robotic and human-piloted missions to Mars should incorporate strategies to test this.[11]

Part of the success of microorganisms in the rocks is due to their very small size, permitting them to exist in very small pore spaces. Bacteria are commonly around 1 mm ($^1/_{1000}$ mm, or $^1/_{25,000}$ in) in diameter or length. Protozoa, algae, fungi and cyanobacteria (bacteria that have photosynthetic capability) are generally 10-100 times larger, but still are an easy fit between particles of coarser sediments such as sands. Moisture is essential for their survival, but water is common in many areas down to 1 km (0.6 mi), and often many times that depth. The slow lateral and vertical transport of water in aquifers favors the passive spread of microorganisms.

Recently it has been discovered that these microorganisms can attack rocks, probably using the organic acids they secrete. This kind of activity is enhanced in the presence of an organic source such as oil.[12] They can also precipitate certain minerals and may thus be insidious sculptors of the subterranean environment, opening and closing groundwater flow-paths.[13] This ability to attack rock is a matter of major concern if radioactive waste is stored in rocks. If this waste and surrounding rocks are attacked by microorganisms, there might be consequent radioactive contamination of groundwater.[3] In shallower environments these microorganisms cause considerable commercial damage, aiding in the corrosion of metals. Rusted and failed pipelines are a problem of massive proportions. In England alone damage is estimated at half a million pounds per year.[14]

The various organisms found at depths possess a multitude of biochemical systems that permit them to survive under unusual conditions. Many require oxygen while others cannot survive in its presence. Others can go either way. Often there is a moderate amount of oxygen in the waters found at these depths, while pockets with no oxygen are not uncommon. Energy is obtained from both organic and inorganic compounds, and a number of ingenious metabolic mechanisms are being discovered.

Often these organisms can survive at unusually high temperatures which are common at these depths. Many thrive at temperatures well above the boiling point for water at sea level (100ºC, 212ºF). At great depths, high ambient pressures keep the water from boiling and provide a fluid, but nevertheless very hot, environment. It is commonly surmised that these organisms could survive at temperatures up to 150ºC (300ºF). The higher temperatures found in rocks at depths beyond a few kilometers would exclude life at such depths. However, the successful culture of bacteria obtained from "black smoker" sulphide chimneys deep in the Pacific Ocean at 250ºC (480ºF) under 265 atmospheres of pressure has been reported.[15] Interestingly, some of the hot springs from the deep floor of the ocean extrude living bacteria in concentrations as high as a billion per milliliter of water.

From the above it is obvious that there is a previously unknown world of life dwelling in the rocks that should be further investigated. Unfortunately these secretive organisms are relatively inaccessible. Their presence poses some interesting questions regarding the fossil record of microorganisms as found in the deeper rocks.

THE GEOLOGIC COLUMN

Recently evolutionists have been placing special emphasis on fossil finds of simpler life among what is considered to be Eaerth's earliest rocks. A review of some of the more important findings as they relate to the geologic column will help in elucidating interpretations.

The major divisions of the geologic column are outlined in Table 1. One can think of these layers as being superimposed, with the oldest being at the bottom. Actually, each of these divisions can be found today on Earth's surface, with the lower ones being exposed by uplift and erosion. The lowest layers have been studied intensively by paleontologists in their search for clues about the earliest forms of evolving life on Earth.

A number of fossil unicellular organisms have been described for the Archean (see Table 1). Study has concentrated on the Swaziland Supergroup of South Africa and the Warrawoona Group near North Pole (so-called because, like the real North Pole, it is a very desolate area) in Australia. From each of these regions, both filamentous types of fossils[16] and stromatolites have been described. Stromatolites are finely layered sedimentary structures, generally of centimeter to meter size, usually in a domed or wavy shape. They are formed by living

TABLE 1. MAJOR DIVISIONS OF THE GEOLOGIC COLUMN

NAME	PUTATIVE AGE IN MILLIONS OF YEARS*	MAIN FOSSIL FINDS
PHANEROZOIC (i.e., Cambrian to Recent)	0-560	Relatively abundant plants and animals of all kinds
PRECAMBRIAN	560-4600	Very few fossils found
PROTEROZOIC	560-2500	Fossils rare; upper-most (recent) layers contain some well-developed animals and plants
ARCHEAN	2500-4600	Fossils extremely rare, only simple organisms found

*Ages not endorsed by author.

organisms, mainly bacteria, that live on the surface of the stromatolite. The bacteria, which usually require light, function in the capture and/or precipitation of sediments that gradually build up the stromatolite.

In the Proterozoic (see Table 1), stromatolites are relatively abundant, especially in the lower part. Special mention should be made of the Gunflint Chert of the Great Lakes region of the U.S. This chert, also from the lower part of the Proterozoic, has well-preserved filamentous fossils that look very much like the modern *Oscillatoria* cyanobacterium (blue-green algae).[17]

Peculiar spherical organisms called acritarchs, which are commonly 50 mm (0.002 in) in diameter and thought to be some form of algal cysts,[18] are found in the upper half of the Proterozoic. They show great diversity and size increase near the top. These are the first generally accepted evidence for organisms with cells containing a nucleus; however, the evidence has been disputed. Organisms with cells that have a nucleus are called the Eukaryotes. These include most kinds of living organisms from protozoa to redwood trees. By contrast, bacteria which have no nucleus are called prokaryotes. Several other fossil types have been described for the Proterozoic, including peculiar small vase-shaped objects (70 mm, 0.003 in) of unknown affinity.

In the very top of the Proterozoic are found mostly unfamiliar Ediacaran multicellular types of animals. No multicellular animals have been found below this level. Directly above this level is the so-called "Cambrian Explosion" at the base of the Phanerozoic (see Table 1),

where the majority of the basic kinds of animals first appear. The scarcity of fossils in the Precambrian is well illustrated by the fact that during the previous century no fossils were found in that portion of the rock layers. Recently the situation has changed.

THE PROBLEM OF FOSSIL IDENTIFICATION

Determining whether a peculiar form in a rock is a bona fide fossil can be difficult. Curls caused by the desiccation of sediments have been interpreted as arthropod parts; drag marks caused by storms can resemble worm tracks; and pyrite rosettes have been interpreted as medusae (jellyfish).[19] The terms pseudofossils and dubiofossils are used to describe false or dubious fossils.

Intensive search by paleontologists for early life has produced many suggested candidates, but authentication is a problem. Many non-biogenic structures can simulate the general shape and characteristics of these assumed early simple cells. Additionally, by simple inorganic chemical precipitation, several workers have succeeded in producing spherical and tube-like structures that highly resemble what is being described as evidence of life in these early layers.[20] It is to the credit of paleontologists that recently a considerable amount of caution is being expressed regarding the authenticity of most of the findings in the early Precambrian rocks. Schopf and Packer, in referring to microfossils reported from at least 28 Archean geologic units, state: "However virtually all have recently been reinterpreted as dubiofossils or as nonfossils: pseudofossils, artifacts, or contaminants."[21] Cowen states: "Only a few reports of fossil Archean cells seem to be genuine out of fifty or more claims."[22] Buick has pointed out a host of problems with the identification of most fossil finds from North Pole, Australia.[23]

Stromatolites have not fared much better. The question is: are they formed biologically or are they just the passive accumulation of fine layers of sediments, possibly subjected to some deformation? Ginsburg points out that "Almost everything about stromatolites has been, and remains to varying degrees, controversial."[24] Hoffman notes: "Something that haunts geologists working on ancient stromatolites is the thought that they may not be biogenic at all."[25] He illustrates this with the notorious example of the "algal pisolites" (rock composed of pen-size spheres) of the Permian in Western Texas which were thought to have been formed biologically in a similar way to stromatolites, but turned out to be of inorganic origin.[26] The well-known paleontologist Charles

Walcott, who for twenty years was Director of the Smithsonian, described 5 new genera and 8 new species of strornatolites which he believed to be of biological origin. All have since been reinterpreted as inorganic by some workers.[27] Interestingly, no cells have been found associated with any Archean stromatolites.

The question of the temporal significance of stromatolites is further complicated by the recent discovery of living stromatolites forming in cavities in rocks such as in coral reefs. These are called endostromatolites. Sediment accumulation would be facilitated by bacteria that do not require light as an energy source. Furthermore, Monty suggests that endostromatolites can form in rock cavities at depths of at least 3000 m (10,000 ft) below Earth's surface.[28] This raises the question as to whether some stromatolites in the Precambrian may actually be endostromatolites of much more recent origin.

Attempts have been made to validate the authenticity of Precambrian fossils by testing for the isotope fractionation of carbon and sulfur that would be expected from biological activity. Some positive results have been obtained, but Buick[23] rejects these outright, since controls are too variable. Knoll[29] comments about little fractionation in sulfur, and Nagy et al.[30] give good evidence of contamination of sediments assumed to be very old by molecules originating from recent organisms.

Despite all the problems in identifying Precambrian fossils, it appears that there are still a few good examples. They include the Gunflint Chert cyanobacteria, the acritarchs, the Bitter Springs cyanobacteria and the Ediacaran animal fauna, all of which are Proterozoic.

SIGNIFICANCE TO THE EVOLUTION VIEWPOINT

Evolutionists have sometimes suggested that the first organisms to evolve were closely related to the sulfur bacteria mentioned above.[10] These are part of a group called the Archeabacteria. Later the true bacteria or Eubacteria are assumed to have evolved from the Archeabacteria, and they developed photosynthetic and stromatolite-building capabilities. The more-advanced forms of life with nuclei in their cells — the Eukarya — are considered to have evolved later. This scenario has been challenged by studies of molecular phylogenies which show evolutionary relationships on the basis of sequential similarities in large organic molecules. Ribosomal RNA is a favorite. It turns out that the two basic bacterial types — the Archeabacteria and the Eubacteria —, which are both simple cells without a nucleus and look very similar to each other,

are as far apart from each other in terms of ribosomal RNA differences as all the rest of the living organisms combined (i.e., from protozoa to redwood trees), which are all Eukaryotes (cells with a nucleus). This surprising result has caused evolutionists to propose that all three groups — Archeabacteria, Eubacteria, and Eukaryotes — evolved very early so as to give equal time for differentiation of the ribosomal RNA molecules according to the molecular-clock hypothesis.[29]

This newer evolutionary concept challenges both the older concept of ancestral Archeabacteria and the findings of the fossil record. Good examples of Eukarya do not appear until the middle of the Proterozoic, and the evidence there is not very certain.[31] On the other hand, in accord with the theory, filamentous Eubacteria are assumed to have existed as far back as the middle of the Archeozoic,[16] and stromatolites are also described there. Hence the molecular clock and the fossil record do not appear to be in synchrony. One could explain this by proposing that the early Eukaryotes were different from modern types and have not been recognized, but more evidence is needed.

One wonders if the newer information regarding the abundance of life in rocks might not modify evolutionary interpretations. Some questions have been raised regarding the primary nature (i.e., are the fossils part of the original deposit?) of a number of Archeozoic fossil finds,[23] but thus far, to this writer's knowledge, the significance of organisms living in rocks as more recent contaminants has not received any attention from proponents of the evolution viewpoint. This evidence has the potential for challenging views that the Precambrian fossils represent ancient simple forms of life in the early stages of evolutionary development.

SIGNIFICANCE TO THE CREATION VIEWPOINT

Creationists have paid little attention to the Precambrian. Traditionally, because of the paucity of fossils, Precambrian sediments have been considered to be deposits made before the Genesis flood. Recent information regarding Precambrian fossils has prompted some reinterpretation. Snelling[32] suggests the Precambrian sediments represent flood deposits, while Wise[33] proposed that the Precambrian fossils represent organisms created on Day 2 of creation week and buried on Day 3. Each of these views deserves further consideration.

I would like to suggest that the Precambrian fossils (except for the Ediacaran metazoa which are very close to the Cambrian) might originate from two sources:

1) Normal life in the rocks as is being found now, and existing at any time since creation. These could be pre-flood, flood, or post-flood in origin.
2) Local infiltration into Precambrian rocks resulting from the upheaval of the Genesis flood. Such an event would be expected to facilitate the inflow of water and organisms along cracks and fault lines into Precambrian rocks.

For each of these sources, Precambrian fossils originate from a recent creation and do not reflect evolutionary development. The Ediacaran animal fossils of the uppermost Precambrian would be considered a flood deposit.

The concept of life in the deep rocks before the flood adds a new dimension for the ecological zonation model of the fossil sequence.[34] That model proposes that the sequence of fossils now found reflects the pre-flood ecology. Under this concept the living organisms in the deep pre-flood rocks would be the source of the fossils we now find in the Precambrian.

One piece of evidence, supportive of a recent origin for Precambrian fossils, deserves mention: the very close similarity of some of the Precambrian fossils to present living forms. Their similarity seems unusual if they have had two billion (2×10^9) years to evolve. Stewart comments on the Bitter Springs cherts of central Australia:

> *Many more examples could be given to emphasize the similarity of the fossils and extant floras which is so striking that one has to wonder about the slow rate of evolution among the Cyanophyta for the last 900 m.y.* [million years].[35]

Schopf reports on several fossil species in this formation that appear identical to present living species.[36] Some forms in the Gunflint Chert, which is assumed to be nearly two billion years old, are also very similar. Speaking more generally, Knoll states:

> *Many Late Proterozoic prokaryotes differ little in morphology, development, or behaviour from living cyanobacterial populations*.[37]

Evolutionists try to explain this lack of change on the basis of an episodic rate of evolution, but these similarities may well represent organisms created recently and found in rocks as part of the living underworld.

CONCLUSIONS

The recent discoveries concerning life in the deep rocks, including algal filaments at 200 m (650 ft) depth, open a whole new field for reinterpretation of the Precambrian record of simple organisms. The problematic strornatolites may represent only deformed sediments or even endostromatolites formed in deep rocks. It is proposed that the small Precambrian fossils (except for those near the upper boundary) could have come from either recently created organisms living in these rocks, or infiltration of these organisms into these lower rocks during the Genesis flood. The presence of abundant microbial life deep in the rocks challenges evolutionists with the necessity of testing the hypothesis that Precambrian microorganisms are recent contaminants, rather than 560 to 3500 million-year-old fossils.

ENDNOTES

1. (a) Ghiorse WC, Wilson JT. 1988. Microbial ecology of the terrestrial subsurface. Advances in Applied Microbiology 33:107-172; (b) Fliermans CB, Hazen TC, editors. 1990. Proceedings of the First International Symposium on Microbiology of the Deep Subsurface. WSRC Information Service Section Publication Group.
2. Ivanov MV. 1990. Subsurface microbiological research in the USSR. In: Fliermans & Hazen, p 1.7-1.15 (see Note 1b).
3. West JM. 1990. Subsurface microbiological research in the United Kingdom. In: Fliermans & Hazen, p 1.16-1.23.
4. Balkwill DL. 1990. Density and distribution of aerobic, chemoheterotrophic bacteria in deep southeast coastal plain sediments at the Savannah River Site. In: Fliermans & Hazen, p 3.3-3.13.
5. (a) Sinclair JL. 1990. Eukaryotic microorganisms in subsurface environments. In: Fliermans & Hazen, p 3.39-3.51; (b) Sinclair JL, Ghiorse WC. 1989. Distribution of aerobic bacteria, protozoa, algae, and fungi in deep subsurface sediments. Geomicrobiology Journal 7:15-31.
6. Sinclair JL, Ghiorse WC. 1987. Distribution of protozoa in subsurface sediments of a pristine groundwater study site in Oklahoma. Applied and Environmental Microbiology 53(5):1157-1163.
7. Bradford SM, Gerba CP. 1990. Isolation of bacteriophage from deep subsurface sediments. In: Fliermans & Hazen, p 4.65.
8. Ourisson G. 1984. The microbial origin of fossil fuels. Scientific American 251(2):44-51.
9. Gold T. 1991. Sweden's Siljan ring well evaluated. Oil & Gas Journal 89(2):76-78.
10. Gold T. 1992. The deep, hot biosphere. Proceedings of the National Academy of Sciences (USA) 89:6045-6049.
11. Boston PJ, McKay CP. 1990. The deep subsurface of Mars: possible habitat for extant or recently extinct microbial life. In: Fliermans & Hazen, p 4.97.
12. Hiebert FK, Bennett PC. 1992. Microbial control of silicate weathering in organic-rich ground water. Science 258:278-281.

13. Appenzeller T. 1992. Deep-living microbes mount a relentless attack on rock. Science 258:222.

14. Hamilton WA. 1985. Sulphate-reducing bacteria and anaerobic corrosion. Annual Review of Microbiology 39:195-217.

15. Baross JA, Deming JW. 1983. Growth of 'black smoker' bacteria at temperatures of at least 250ºC. Nature 303:423-426.

16. (a) Schopf JW, Packer BM. 1987. Early Archean (3.3-billion to 3.5-billion-year-old) microfossils from Warrawoona Group, Australia. Science 237:70-73; (b) Walsh MM, Lowe DR. 1985. Filamentous microfossils from the 3,500-Myr-old Onverwacht Group, Barberton Mountain Land, South Africa. Nature 314:530-532.

17. Stewart WN. 1983. Paleobotany and the evolution of plants. Cambridge, NY and London: Cambridge University Press, p 30.

18. Mendelson CV. 1993. Acritarchs and prasinophytes. In: Lipps JH, editor. Fossil Prokaryotes and Protists. Boston, Oxford and London: Blackwell Scientific Publications, p 77-104.

19. Cloud P. 1973. Pseudofossils: a plea for caution. Geology 1(3):123-127.

20. (a) Pickett J, Scheibnerová V. 1974. The inorganic origin of "anellotubulates." Micropaleontology 20(l):97-102; (b) Merek EL. 1973. Imaging and life detection. BioScience 23(3):153-159; (c) Gutstadt AM. 1975. Pseudo- and dubiofossils from the Newland Limestone (Belt Supergroup, late Precambrian), Montana. Journal of Sedimentary Petrology 45(2):405-414.

21. Schopf & Packer (Note 16a).

22. Cowen R. 1990. History of life. Boston, Oxford and London: Blackwell Scientific Publications.

23. Buick R. 1990. Microfossil recognition in Archean rocks: an appraisal of spheroids and filaments from a 3500 m.y. old chert-barite unit at North Pole, Western Australia. Palaios 5:441-459.

24. Ginsburg RN. 1991. Controversies about stromatolites: vices and virtues. In: Müller DW, McKenzie JA, Weissert H, editors. Controversies in Modern Geology: Evolution of Geological Theories in Sedimentology, Earth History and Tectonics. NY: Academic Press, p 25-36.

25. Hoffman P. 1973. Recent and ancient algal stromatolites: seventy years of pedagogic cross-pollination. In: Ginsburg RN, editor. Evolving Concepts in Sedimentology. Baltimore and London: The Johns Hopkins University Studies in Geology No. 21, p 178-191.

26. (a) Thomas C. 1968. Vadose pisolites in the Guadalupe and Apache Mountains, West Texas. In: Silver BA, editor. Guadalupian Facies, Apache Mountains Area, West Texas. Symposium and Guidebook 1968 Field Trip, Permian Basin Section, Society of Economic Paleontologists and Mineralogists Publication 68-11; (b) Estaban M, Pray LC. 1975. Subaqueous, syndepositional growth of in-place pisolite, Capitan Reef Complex (Permian), Guadalupe Mountains, New Mexico and West Texas. Geological Society of America Abstracts with Programs 7:1068-1069.

27. Gutstadt (Note 20).

28. (a) Monty CLV. 1986. Range and significance of cavity-dwelling on endostromatolites. Sediments Down-Under. Abstracts of the 12th International Sedimentological Congress, Canberra, Australia, p 216; (b) Vachard D, Razgallah S. 1988. Survie des genres Tharama et Renalcis (Epiphytales, a1gues problématiques) dans le Permien supérieur du Djebel Tebaga (Tunisie). Comptes Rendus De L'Académie des Sciences Paris 306(Series II):1137-1140.

29. (a) Knoll AH. 1990. Precambrian evolution of prokaryotes and protists. In: Briggs DEG, Crowther PR, editors. Palaeobiology: A Synthesis. Oxford and London: Blackwell Scientific Publications, p 9-16; (b) Woese CR. 1987. Bacterial evolution. Microbiological Reviews 51(2):221-271.

30. Nagy B, Engel MH, Zumberge JE, Ogino H, Chang SY. Amino acids and hydrocarbons ~3,800-Myr old in the Isua Rocks, southwestern Greenland. Nature 289:53-56.

31. Knoll AH. 1992. The early evolution of Eukaryotes: a geological perspective. Science 256:622-627.

32. Snelling A. 1991. Creationist geology: where do the 'Precambrian' strata fit? Creation Ex Nihilo Technical Journal 5(2):154-175.

33. Wise K. 1992. Some thoughts on the Precambrian fossil record. Creation Ex Nihilo Technical Journal 6(l):67-71.

34. Clark HW. 1946. The new diluvialism. Angwin, CA: Science Publications.

35. Stewart, p 31 (Note 17).

36. Schopf JW. 1968. Microflora of the Bitter Springs Formation, Late Precambrian, central Australia. Journal of Paleontology 42:651-688.

37. Knoll 1990, p 15 (Note 29).