

# EDITORIAL

## PUBLISHING ANYTHING — OR PERISH

The discovery of the Tasaday tribe in the southern Philippines in 1971 has been hailed as the “anthropological find of the century.” Characterized as “ultraprimitive,” “lost,” and “Stone Age,” the 26 individuals, living in caves located in a rain forest, pursued a paleolithic lifestyle surviving at the “most elemental levels of human existence.” They wore only leaves for clothing and knew nothing about hunting or agriculture. They survived on berries, roots and wild bananas, as well as crabs, grubs and frogs. They did not know of a large village just a three-hour walk away, or of the ocean 20 miles away, and were even reported to regard themselves as the only people on Earth. Their language was unique, although close enough to a known language used in the vicinity to permit translation.

Discovery of the Tasaday tribe attracted worldwide attention, and government agents closely regulated visits to the last two dozen Stone-Age cavemen of the world. The public media and about a dozen scientists were allowed to view and interview the Tasaday through interpreters, but only for a few hours a day. Coverage to the general public was abundant, scientific reports more limited. The National Geographic Society, whose journal has a circulation of 8 million, published two articles on the group. They and NBC each prepared television programs which were shown worldwide. A book entitled “The Gentle Tasaday”<sup>1</sup> received wide circulation.

Three years later all communication with the Tasaday was stopped and could not be resumed until twelve years later when major political changes in the Philippines altered enforcement of isolation. It was then that a Swiss anthropologist-reporter made his way to the caves and found them empty. He found the Tasaday wearing colored T-shirts, using metal knives, and sleeping on beds. One member of the group reported that they used to live in huts and had done some farming but that government agents had forced them to live in caves so that they would be called cavemen.<sup>2</sup> A few days later some reporters from Germany also contacted the Tasaday and photographed one of the same individuals the Swiss reporter had photographed. This time the “caveman” had reverted to a garment of leaves; however, cloth underwear was showing under the leaves. All this and more precipitated the conclusion that the Tasaday were a hoax. It also generated a major controversy in the anthropological community.

Upon his return to Switzerland, the reporter who discovered the Tasaday living under much more modern conditions immediately called the National Geographic Society, offering them his new information. They sent him a telegram the next day indicating that they were not interested and did not reply to

a follow-up letter. Two years later the *National Geographic Magazine* reported that the idea that the Tasaday were a hoax had been “largely discredited.”<sup>3</sup> On the other hand, two TV documentaries identified the Tasaday story as a deception. The first was produced by ABC-TV in 1986, entitled “The Tribe That Never Was,” and the other “Scandal: The Lost Tribe,” was shown on NBC-TV in 1987.

Many wonder whether the Tasaday are a genuine “Stone-Age” tribe. Could such a group survive and remain isolated while living in such close proximity to more advanced groups. Most of the early anthropologists who saw the “tribe” support their primitiveness and authenticity. However, after it was suggested that the Tasaday might be a hoax, three international anthropological conferences have been held regarding this challenging question. At stake is the propriety of the governmental agencies supervising the Tasaday, the integrity of the Tasaday, and the credibility of the science of anthropology which occasionally still hears echoes of the Piltdown hoax.

There is little question but that the Tasaday represent a unique group living under somewhat primitive conditions. There also seems to be a fair amount of consensus that they were coerced into orchestrating a caveman show for publicity or economic reasons, which is sometimes referred to as the “rain forest watergate.”<sup>4</sup> It is also agreed that they could have undergone many changes between their first discovery in 1971 and their rediscovery in 1986. Beyond that many questions remain unresolved, a number stemming from positions taken during the early years when they were first discovered versus newer interpretations.

One of the more important questions about the Tasaday is whether their language is sufficiently different to justify claiming isolation of the group for any length of time from neighbors with closely related languages. Opinions between a number of scholars in this area vary widely. The Tasaday had three stone tools in 1971 which mysteriously disappeared before they were ever photographed. They represented the only extant use of stone tools in the Philippines. Some substitute tools made by the Tasaday or their neighbors at the request of government authorities have been categorized as obvious fakes. Another controversy centers on the genealogical data with confusion as to which anthropologist collected the correct information. This has important implications regarding the degree of isolation of the Tasaday. Also much disputed is the question of the adequacy of the purported diet of the Tasaday. Some feel that the forest in which they were supposedly secluded could not have sustained them. Carbohydrates would be in especially short supply; others disagree. Many other points of contention could be listed, but the above should suffice to illustrate the diversity of the conflicting reports.<sup>5</sup>

As one takes a broad view of this whole caper, one has to wonder how so many things could go wrong. Scientists should be careful in communicating

with the public press, radio and television which seldom can correctly represent what they are trying to say. Besides that, a controversial issue such as the Tasaday is prime turf for exploitation by the public media which gain more rating points for excitement, mayhem and carnage than for accuracy.

Another point of great import concerns accuracy of reporting in the professional literature. The great discrepancy in conclusions expressed on a variety of topics about the Tasaday is, to say the least, bewildering. Far too much has been published without adequate supporting data, and once an investigator has adopted and published a position, it is more difficult to back down. Too often initial publication is followed by the traditional interdisciplinary dispute. One wonders whatever happened to the concept of doing thorough research and making sure one has sound conclusions before publishing. Members of the academic community are under great pressure to publish in order to justify their investigations, but this should be fully subordinate to accuracy. The traditional maxim of “publish or perish” is too often becoming “publish anything or perish.” One professional journal quotes the philosopher Lakatos:

*Wastepaper baskets were containers used in the seventeenth century for the disposal of some first versions of manuscripts which self-criticism — or private criticism of learned friends — ruled out on the first reading. In our age of publication explosion, most people have no time to read their manuscripts, and the function of wastepaper baskets has now been taken over by scientific journals.<sup>6</sup>*

Our “scholarly” literature has become so vast it is unwieldy. Unfortunately, the quality of what is presented often leaves much to be desired. There is much room for improvement. We would all be served better by fewer, but higher-quality publications.

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## ENDNOTES

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5. For general references on the Tasaday, see: (a) Nance (Note 1); (b) MacLeish K. 1972. Stone Age cavemen of Mindanao. National Geographic 142(2):219-249; (c) [no author listed]. 1971. First glimpse of a Stone Age tribe. National Geographic 140(6):880-882b; (d) Bower B. 1989a. A world that never existed. Science News 135:264-266; (e) Bower B. 1989b. The strange case of the Tasaday. Science News 135:280-281, 283; (f) Headland (Note 2).
6. Lakatos I. Quoted in Palaios 2(5):445.

# ARTICLES

## AN ALTERNATIVE EXPLANATION OF OCEANIC MAGNETIC ANOMALY PATTERNS

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### WHAT THIS ARTICLE IS ABOUT

*The oceanic patterns of magnetic anomalies are thought to be one significant evidence supporting the general notions of plate tectonics. Arguments are presented suggesting that important characteristics of the anomaly patterns could be due to the measurement process itself rather than being a direct reflection of geomagnetic reversals and plate movement, as is usually claimed. While it is certainly true that this reinterpretation does not disprove the popular explanation of anomaly pattern formation, it does open the door to exploration of various alternative explanations.*

### INTRODUCTION

Over the last several decades, a general theory of large-scale geophysical behavior of the earth, known as plate tectonics, has gained wide acceptance. This theory has been able to provide a unified explanation of a wide variety of geophysical phenomena, doing so within the world view held by the majority of the academic community. The general theory is an integration of several concepts which fit consistently together (see for example, Uyeda 1978, and Takeuchi, Uyeda & Kanamori 1970). This article concerns itself with only one of these, the origins of the oceanic magnetic anomalies. Before describing the motivation for and the main thought of this article, we will give a brief

introduction to the general theory of plate tectonics. This introduction will focus on four of the prominent concepts in the general theory.

The concept which first gained prominence was that of continental drift. Although it is often associated with its most active proponent, Alfred Wegener, anyone looking at a world map could observe that if the American continents could somehow slide up against Europe and Africa, the coastlines would fit together remarkably well. According to the continental-drift concept, the continents originated from the breakup of one large land mass (presumably a couple hundred million years ago) and subsequently, slowly “drifted” to their present positions. In the early part of this century, Wegener and his associates marshalled a great deal of evidence supporting this idea. Although the concept was widely discussed, interest later waned, mainly because of a lack of independent evidence which would corroborate continental-plate motion. Toward the middle of the century, several areas of investigation produced data that revived interest.

The thought that continents in the past were arranged differently is of interest in itself, but the concepts of plate tectonics in general, and continental drift in particular, play a central role in modern geophysics far beyond mere historical interest. The motion and collision of the continental segments provide a rather unified explanation, either directly or indirectly, for most geological features. For example, the Himalayas are thought to have arisen from the collision of India with Asia.

One area of investigation that produced data which revived interest in continental drift is continental paleomagnetism. This data collection began in the 1950s. Samples from rock formations, most notably those taken from bedrock, generally have a low-level “remanent” magnetism. The orientation of this remanent magnetism is thought to indicate the orientation of Earth’s magnetic field at the time of emplacement of the rock, specifically, the orientation at the time of cooling. Sample orientations from local deposits are usually averaged to obtain a magnetic-pole position for that formation. Averaged pole positions obtained from rocks of roughly similar geologic age in a given region tend to be similar, except for one modification. That modification is a 180° flip in the polarity indicated for about half of the averaged pole positions. From these observations has come the notion of a historical sequence of polarity reversals of Earth’s magnetic field. The reversals are thought to occur randomly at an average rate of a few per million years. [However,

there are indications that these reversals can occur in a few months (Brown 1989).]

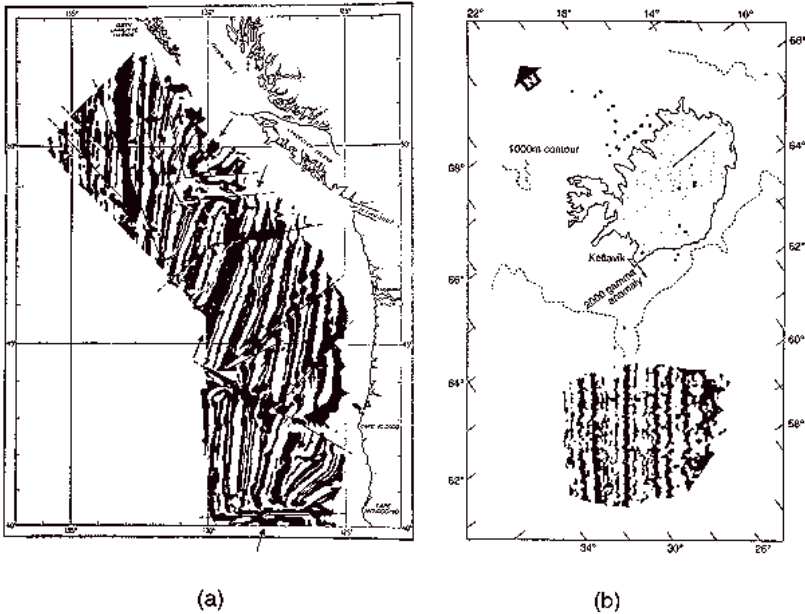
A plot of a continent's indicated pole position as a function of geologic age is useful in reconstructing past continental motion. However, the concept of an historical sequence of geomagnetic reversals, not geomagnetic-pole positions, is of most significance to the topic of this article.

The notion of seafloor spreading played an important part in the wide acceptance of the general plate-tectonics concept. Seafloor spreading provides a reasonable mechanism for continental drift.

The crust of the earth can be thought of as divided into several relatively rigid plates slowly moving relative to one another. The boundaries of these plates correspond to a network of faults, oceanic trenches and mid-ocean ridges. The relative plate motions are believed to be driven by patterns of circulation deep in the underlying semifluid mantle. This motion is analogous to the motion of various segments of scum on the surface of a pan of syrup that is heated enough to cause circulation, but short of the boiling point. The scum stays on the surface but is moved about by the circulation of the syrup. The mantle circulation is thought to rise under the mid-ocean ridges and then to flow away from the ridges in both directions. As the crust is carried away from a ridge in both directions by riding on this circulation, new crust is formed at the ridge by mantle material cooling in the "fissure" — hence the phrase sea-floor spreading. As new crust is formed at the mid-ocean ridges, old crust must be destroyed elsewhere. In the plate-tectonics theory, this destruction occurs at a downturn of the crust into the mantle at subduction zones generally corresponding to oceanic trenches. Lateral motion of plate edges forms transverse faults that complete the boundary network. Continental drift occurs as the continents are carried along as parts of the moving plates.

Of special interest to our discussion is the formation of the "oceanic magnetic anomalies." The currently accepted interpretation of these magnetic anomalies provides a wealth of detail for refining the reconstruction of past plate movements, and for many it provides the "clinching" argument in support of the general plate tectonics theory.

Fairly detailed surveys of the intensity of the magnetic field at the ocean surface have been made over most of the world's oceans. This magnetic intensity shows an interesting pattern of variation about its



**FIGURE 1. Magnetic anomaly patterns in the East Pacific off Vancouver Island (a) and southwest of Iceland (b). Positive anomalies are shown in black. After Raff & Mason (1961) and Vine (1966) (a), reproduced with permission of the publishers; and after Heirtzler, Le Pichon & Baron (1966) (b).**

local average value. These variations are often called magnetic anomalies. When maps are made showing regions of above average and below average intensity, the regions form a striped pattern as illustrated in Figure 1. The stripes are usually a few tens of kilometers wide. Most interestingly, the stripes usually are roughly parallel to the nearest ocean ridge.

Vine and Matthews (1963) provided the “ah ha” insight that fit these oceanic magnetic anomalies into the general scheme of plate tectonics. They observed that as new crust cools at the ridge, it would take on the magnetic orientation and polarity of the then-current geomagnetic field. By this new crust moving gradually away from the ridge, a band of crust of this polarity is formed adjacent to the ridge. When the geomagnetic polarity reverses, a new band of opposite polarity is started. As time goes on stripes of alternating polarity move away

from the ridge center. In this way the ocean floor becomes a sort of “tape recording” of the historical sequence of geomagnetic polarity reversals. One could expect a mild disturbance of the striped patterns due to faulting, and such is observed.

The Vine and Matthews explanation of oceanic magnetic anomalies is one of the major supports for the notion of seafloor spreading. However, even if the concept of large-magnitude seafloor spreading is accepted on the basis of other evidence, the interpretation of the magnetic anomalies is of considerable significance. The manner and global coordination of seafloor spreading would be only vaguely conceptualized without the magnetic anomaly data. The point of the Vine and Matthews explanation is not just that geomagnetic reversals have somehow been involved in the formation of the magnetic anomalies, but that there is a rather precise one-to-one correspondence between the magnetic anomaly sequence and a historical sequence of geomagnetic reversals. Because of the global nature of the geomagnetic reversals, acceptance of this correspondence provides a wealth of relatively precise detail on the global coordination of seafloor spreading and the manner in which it occurred. For example, one would know that the thirtieth anomaly bands away from ridge centers were at one time being simultaneously formed at the ridges. Thus, if accurate age data were available, a plot of continental position versus time could be constructed. If this picture of spreading history is accepted as established fact, the possible scenarios for geophysical history are considerably restricted.

Although there are other notions and a great amount of further elaboration involved, the above concepts are the “core” of the plate-tectonics theory.

## MOTIVATION

This article will suggest, and to a degree explore, an alternative to the generally accepted explanation for the origin of the oceanic magnetic anomalies. We do not claim to show that the generally accepted explanation is false. Therefore, additional discussion of the motivation for this article (alluded to in the Introduction) is provided here.

To a person who is exploring general theories of origins which are alternatives to those popularly accepted in academic circles, it is important not to unduly restrict the range of possible explanations open



for consideration in each of the many areas which a general theory must address. In a given area of study, one usually finds a group of alternatives which the physical evidence itself would eliminate from further consideration; however, there often remains a range of possibilities for each of which the physical evidence is not conclusive pro or con. To those interested only in theories fitting within the conventionally accepted world view, many of these remaining possibilities may be dropped from consideration. But such possibilities may actually be essential elements of some alternative theory of origins.

Such is the case discussed in this article. The claim is made here that an alternative against which current physical evidence is not conclusive has not been adequately explored. The authors suggest that acceptance of the conventional explanation as proven fact, as seems to be the case in most recent treatments of the subject, is at present an unwarranted restriction of the possibilities open for serious consideration.

### **THE CASE FOR THE CONVENTIONAL VIEW**

In the general literature, little attempt is made to distinguish between the case for the conventional explanation of the anomalies and that for the general concept of seafloor spreading. Because the claim of this article is not directly related to seafloor spreading, care will be taken to distinguish between the evidence related to seafloor spreading and the evidence related to origins of magnetic anomalies.

It would seem that the primary reason for the wide acceptance of the conventional explanation of the origin of the oceanic magnetic anomalies, is that it nicely ties together the notions of seafloor spreading and a historical sequence of geomagnetic reversals. There is, however, also other evidence for seafloor spreading. Among these are the remarkable (yet not precise) fit of the continental shelf boundaries; the layering pattern of oceanic sediments; a degree of symmetry of geologic features across ocean ridges; a pronounced parallelism of oceanic features to the ocean ridges; the plate movements detected by intercontinental interferometry; the geophysical characteristics of transverse faults and oceanic trenches and the coincidence of the pattern of earthquake epicenters with the global network of ridges, transverse faults and trenches.

It is conceivable that the most compelling evidence for the conventional explanation of the anomalies could come from a direct exami-

nation of the magnetic orientation of the oceanic basement rock beneath the sedimentary layers. (It is generally agreed that the origin of the anomalous effects must be in the upper few kilometers of the basement.) What if the basement rock of each anomaly band were widely sampled and directly found to have a uniform remanent magnetic polarity and that adjacent bands were of opposite polarity? What if in addition, the only geologic feature distinguishing adjacent anomaly bands were shown to be this magnetic polarity? If such were the case, the conventional explanation of sequential formation of the anomaly bands in one-to-one correspondence with geomagnetic reversals, would be a strong contender indeed. Unfortunately, as one might expect, such information is not currently available.

The Deep Sea Drilling Project has drilled the ocean floor in many locations but generally these holes are confined to the sedimentary layers (see Hall & Robinson 1979, Hall & Ryall 1977, Smith 1985, and Smith & Banerjee 1986). Only three or four holes have penetrated the basement to any great degree. These few holes have shown a wide scatter of magnetic inclinations within each hole and have not demonstrated lateral continuity. In the real world one would not expect the simplistic uniformity pictured at the beginning of this paragraph, yet one might hope for considerably greater uniformity than has been observed. While explanations can be found for the lack of uniformity, one might contend that direct examination of basement rock magnetic orientation has not currently provided strong support for the conventional explanation of magnetic anomalies.

Close examination of seafloor magnetic orientation has also been done by using deep towed sensors and to a very limited extent by submersibles such as ALVIN. The results have been equivocal (see MacDonald et al. 1983; Luyendyk 1969; and Klitgord et al. 1975).

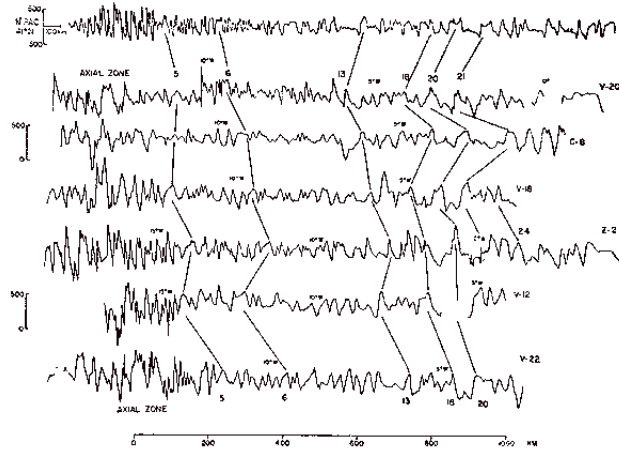
Another area from which one might expect "direct" evidence relating to the interpretation of magnetic anomalies is the correspondence of the anomalies with independently determined geologic ages. Correspondence might be expected in two forms if the conventional explanation is correct. First, one would expect independently determined ages for the anomaly bands to be consistent with each other globally. Second, one would expect such ages determined for anomaly bands to be consistent with the ages determined for the corresponding geomagnetic reversals from continental paleomagnetic studies.

There is a scarcity of studies addressing the degree of such correspondence. A lack of interest in such studies would be understandable since the conventional explanation of anomalies is usually regarded as established fact. Relevant data are not abundant (relative to the task) since usable age determinations need to be taken from cores taken down to the basement rock. Regarding global age consistency of the anomaly bands, one might presume there is at least an approximate consistency since the literature is not replete with cases to the contrary. However, is the correspondence close enough to justify full confidence? If one grants that seafloor spreading has occurred, one could expect an approximate correspondence of age with distance from a ridge. Since the anomalies have a fairly even spatial distribution, one could expect an approximate consistency of anomalies with age, whether or not geomagnetic reversals were involved. It would require a rather tight correspondence to provide evidence of some other global factor as the cause, such as the geomagnetic reversal sequence.

Consistency of the oceanic anomaly reversal dates with reversal dates determined by continental paleomagnetism was addressed in an early paper by Heirtzler et al. (1968). A practical difficulty arises since continental samples are not sequenced in time by some independent process as could be the case with seafloor spreading. Continental reversal ages cannot be determined past about five million radioisotope years, the age at which the reversal durations are about equal to age resolution. Due to this limitation, Heirtzler et al. (1968) had to extrapolate by an order of magnitude using an assumed uniform spreading rate. That the correspondence came within a factor of two would seem strongly in favor of the conventional explanation of magnetic anomalies. That it was not even better might be mildly against it.

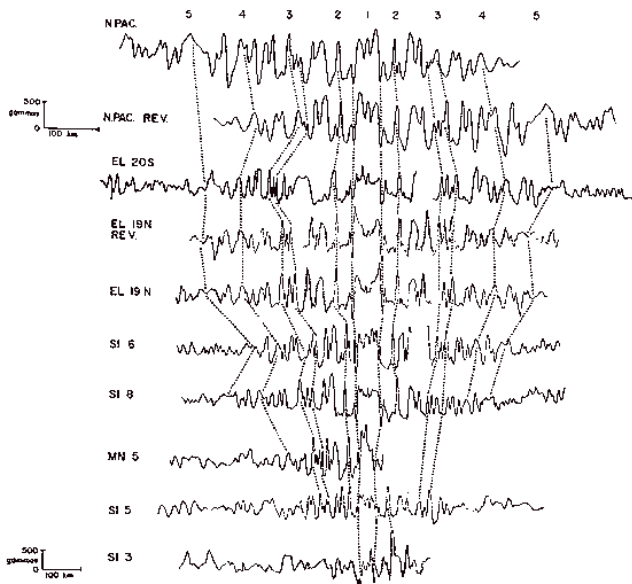
An additional area of direct evidence relating to the interpretation of oceanic magnetic anomalies involves widespread comparisons of magnetic anomaly patterns. This is the area perhaps most often cited as yielding support for the conventional explanation of Vine and Matthews. If the formation of oceanic magnetic anomalies is indeed due to the global effect of geomagnetic reversals, one would expect a global similarity of the anomaly patterns produced. One would also expect a symmetric similarity from opposite sides of a ridge. The matching of anomaly patterns is called correlation.

As is usually the case, the comparison is corrupted by other considerations. Binary anomaly patterns such as shown in Figure 1 are developed



**FIGURE 2.** Magnetic profiles from the South Atlantic east of the mid-Atlantic ridge and a profile from the North Pacific. Vertical scale in gammas. From Dickson, Pitman III, & Heirtzler (1968).

**FIGURE 3.** Magnetic profiles from the Pacific. From Pitman, Herron & Heirtzler (1968).



from intensity traces such as those in Figures 2 and 3. One of the most objective methods for generating the binary pattern is to compare the intensity to some threshold (usually average) value. Still, it is possible for small changes in the threshold used to cause dramatic changes in the binary sequence in areas of low intensity variation. Also, it is generally agreed that some local expansions and compressions should be allowed to accommodate local variation in the spreading rate. Allowances for such effects could in itself allow binary sequences to appear quite similar. For correlation comparisons, it is better to use the intensity traces.

A glance at Figures 2 and 3 reveals that any correlation of intensity traces is not exact (see also Brozena 1986). This should not be surprising even if the conventional explanation is true, since this is real world geologic data that is often corrupted by variation introduced from a multitude of sources. In this case the main source could be the intermittent nature of crust formation.

Maps of oceanic geologic features other than magnetism also reveal a striking orientation parallel to the ridges. Faults, dikes and linear volcanoes roughly parallel to the ridge are thought to be common. That such features could contribute to the similarity of traces crossing a ridge separated by considerable distances would not seem an unreasonable possibility. Also one can observe a degree of symmetry of geologic features across the ridges. Obviously, the extent of such symmetry, especially below the floor, is not clearly known. The degree to which such symmetry and parallelism increase the similarity between traces globally and across ridges is surely open to conjecture, further clouding the conclusions to be drawn from trace correlation.

In Figures 2 and 3 the correlations are indicated by the vertical lines between traces. These figures are rather representative of traces near to the ridges. Generally it can be noted that the shapes of individual peaks (and valleys) are of little help in correlations. Sudden changes in overall amplitude that extend for several peaks and individual isolated large peaks are easier to match. At times groups of peaks have a similar spacing. Generally speaking, it appears that correlation is better in the Pacific, Figure 3, than in the Atlantic, Figure 2, and it appears that the gross features of the traces are better correlated than the individual peaks. The remarkable symmetry of trace EL19N, Figure 3 (compared with EL19N reversed), across the ridge appears more the exception than the rule.

There is a question as to how close such correlations must be to provide strong evidence that the conventional explanation of the anomalies is correct. The evaluation of such correlations and the assessment of their implications is a subjective matter. The simulated correlations shown later are intended to assist in the evaluation of degrees of correlation in a comparison of the conventional explanation with the alternative explanation to be suggested shortly.

In summary, there appears to be nothing in the directly related evidence that would preclude acceptance of the conventional Vine and Matthews explanation of the origin of the oceanic magnetic anomalies. That the evidence permits the conventional explanation is, of course, significant. It is the subjective view of these writers, however, that the direct evidence is less than compelling.

### **AN ALTERNATIVE EXPLANATION**

As explained earlier, the motivation of this article is to help delineate the widest range of possible explanations that are not directly precluded by the physical evidence. This attitude prompts a search for alternative explanations. Two observations have led to the alternative suggested below.

The first observation is that the appearance of the oceanic magnetic intensity traces is quite similar to what in harmonic analysis is called band limited noise. In other words, the traces look like the result of some system that is varying randomly but is constrained to vary neither too slowly or too quickly with distance.

The second observation is related. One can think of several possible causes of spatial variation in magnetic intensity as one moves away from the ridge. What could give such variations their observed appearance of moderate regularity? It is known that a fairly irregular fine-grained variation can be made to appear coarser and more regularly varying by averaging over local regions. [In harmonic analysis talk, this is saying that broad band noise can be made band limited by applying a moving average filter (see Lee 1960, and Bracewell 1978).] If this could be the case, what could be causing the averaging? The clear candidate here is the measurement process itself. The intensity measurements are (generally) made from surface vessels which travel several kilometers above the ocean floor, and more above the basement rock. The intensity measured at any surface point is thus actually the

(weighted) average effect of the intensities in the basement rock for a horizontal distance of several times the vertical distance to the measuring device. This is indeed about the width of the anomaly peaks in the intensity traces. Is this a coincidence? If so, perhaps it is as interesting a “coincidence” as the “within a factor of two” match between observed anomaly geologic ages and the extrapolation from continental data mentioned earlier as evidence for the conventional explanation.

The alternative explanation suggested here is, then, that the observed oceanic magnetic anomaly surface traces are the result of the measurement “filter” applied to an in-part finer variation not in one-to-one correspondence with a historical sequence of geomagnetic reversals.

The question that immediately comes to mind regarding this alternative explanation is what could cause the pronounced orientation parallel to a ridge. The recognizable anomaly stripes are a few tens of kilometers wide but are many tens even hundreds of kilometers long parallel to a ridge. The stresses and strains associated with a ridge appear to be oriented to produce geophysical features parallel to a ridge. Could these forces produce faults and dikes many tens even hundreds of kilometers long parallel to a ridge yet separated by only a few kilometers perpendicular to a ridge? The answer is not clearly known. While the matter certainly invites further investigations, at present it would appear to be an open possibility.

Another question might come up of whether this suggestion has enough substance to deserve being dubbed an alternative hypothesis. It does explain the observed behavior in terms of the physical measurement process but it also resorts to random variation of speculative origin. Speculation is, however, not uncommon in this area of study. Perhaps what it is called is not so important as that it gives insight for another possibility that invites further investigation.

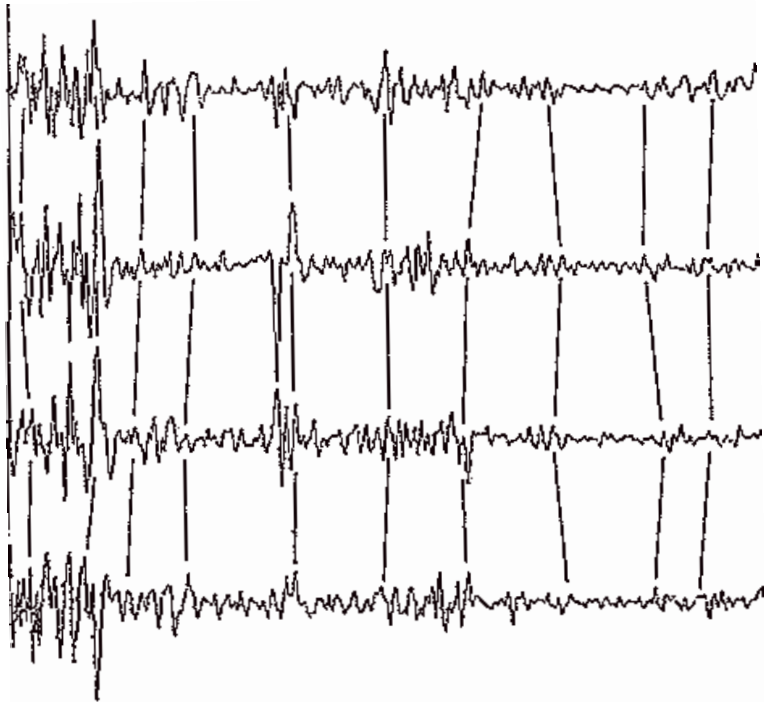
### **SIMULATING THE ALTERNATIVE**

Two questions prompt the simulation described in this section. The first is how similar in general appearance to the observed intensity traces, are traces produced by the measurement process acting upon randomly generated intensity variation of primarily finer grain. The second is whether the correlations observed between widely separated observed traces are impressively better than are the correlations

between randomly generated and averaged traces. Both questions address whether the alternative described above could be a reasonable explanation for the oceanic magnetic anomalies. The answer to the second question will give a rough idea of how good correlations would need to be in order to be impressive evidence favoring the conventional explanation.

The simulation first generated a sequence of magnetic polarity variations of finer grain (i.e., spacing) than the grain of the magnetic anomalies. Variations of grain size and the nature of the random generating process did not make much difference in the appearance of the resulting traces. The fine variation was then filtered by a model of the measurement process. Again reasonable variations in the measurement model made no drastic difference in the appearance of the results. (The variation in the modeled ocean depth was an exception, of course.)

**FIGURE 4. Illustration of degree of apparent correlation between randomly generated 800 km traces with a few overall amplitude step changes.**





Four traces were simulated using different seeds for the random generator to obtain Figure 4. In generating this figure, large-scale amplitude changes (between “regions”) were modeled using nine arbitrary amplitude steps common to all four traces; these are fairly clear in the figure.

It should be emphasized that this simulation is not an attempt to fit any particular observed trace by applying the measurement model to a sequence of blocked variations adjusted to obtain a fit. This exercise has been done repeatedly in the literature with coarse blocks as input; it could certainly be done more easily with fine. Here the input was randomly generated and not adjusted to obtain a fit. The fitting type of exercise is appropriately done by one who already accepts the conventional hypothesis, to obtain detailed information on the underlying reversal sequence. The simulation here was done to illustrate general behavior.

The few correlations drawn in Figure 4 were selected visually. One would suppose that there is a heavy visual component also in the selection of correlations shown in the literature. Individual peak correlations were not drawn in Figure 4 in order to mimic the appearance of Figures 2 and 3.

Evaluation of the questions at the beginning of this section is, of course, very subjective; here is the judgment of these writers. First, the general appearance of the simulated traces is quite similar to the observed traces. The peaks have about the same degree of regularity in both. Degree of variation in peak shape is similar in both. Second, with the exception of the EL19N example and its reverse in Figure 3, the correlations between the random simulated traces are of about the same quality as those between the observed traces. In both, individual peak shape is of little use in correlation. In both, to achieve a one-to-one peak correspondence, the peak counts must be fudged a little by counting minor peaks where necessary or by lumping some somewhat distinct peaks into one. In both, there are regions of little obvious similarity. In both, pronounced correlations between peak groups “fizzle out” upon passing to yet other traces.

From these evaluations, these writers would draw the following subjective conclusions. As far as is revealed by this simulation, the alternative explanation described earlier is a viable possible explanation of the origin of oceanic magnetic anomalies. With isolated exceptions, the correlations drawn between observed magnetic traces are not of

sufficient quality to constitute a strong support for the conventional Vine and Matthews explanation of the origin of oceanic magnetic anomalies.

### SUMMARY

No claim has been made in this article that either the “plate tectonics theory” in general or the Vine and Matthews explanation in particular has been shown to be false. The admittedly subjective evaluation has been made here that the presently documented direct evidence relating to the Vine and Matthews explanation of oceanic magnetic anomalies is equivocal. If the jury is not still out, it would seem that it should be.

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# ANNOTATIONS FROM THE LITERATURE

## BIOGEOGRAPHY

Read J, Francis J. 1992. Responses of some Southern Hemisphere tree species to a prolonged dark period and their implications for high-latitude Cretaceous and Tertiary floras. *Paleogeography, Paleoclimatology, Paleogeology* 99:271-290.

**Summary.** Fossils of trees are found in Antarctica, Australia and South America in Cretaceous and lower Tertiary sediments believed deposited when those areas were within the Antarctic Circle. This raises the question as to how trees could survive in a region that is too cold at present for tree growth. Two to three-year old seedlings of several Southern Hemisphere tree species were grown under controlled conditions of temperature and exposed to ten weeks of continuous darkness. Trees were examined for tissue damage at the end of the dark period. Most trees survived quite well, with little tissue damage. Those that suffered the most were *Banksia grandis* (family Proteaceae) and *Nothofagus betuloides* (Southern beech). Some species of *Nothofagus* suffered no notable damage. Trees generally did better at 4°C than at 15°C, probably because of reduced loss of carbon due to respiration. Ten weeks probably do not give enough time to draw conclusions, but the main problem in explaining the apparent growth of Cretaceous and Tertiary Antarctic trees might be that the temperatures appear to have been high enough to maintain respiratory rates that could have led to tree starvation during the prolonged periods of darkness.

## BIOSTRATIGRAPHY

Sweet WC, Yang Z, Dickins JM, Yin H (editors). 1992. Permo-Triassic events in the eastern Tethys. Cambridge and NY: Cambridge University Press.

**Summary.** This book discusses the biostratigraphy and geology of the Permo-Triassic boundary in the Old World, with emphasis on Asia. One or more chapters are devoted to biostratigraphy of the

boundary in India, China, Russia, Europe and Australasia. Conodont stratigraphy is discussed in two chapters, and the pollen and spores of Israel are discussed in one chapter. The geology, geochemistry and tectonism of the boundary are discussed in three respective chapters. The authors document dramatic faunal and floral changes across the Permo-Triassic border, but do not agree on the causes. Yin Hongfu et al. (Ch 13) favor volcanism over extraterrestrial impact, but Chai Chifang et al. (Ch 14) advocate the involvement of both volcanism and impact. The widespread evidence of Permo-Triassic volcanism was mentioned by several authors. The most impressive example of this is the Siberian Traps, a lava outflow covering 1.5 million km<sup>2</sup>. The Emeishan Basalt in China is estimated to cover an additional 0.3 million km<sup>2</sup>, and other lava outflows are known in Permian or Triassic strata (Ch 13). Both the Upper Permian and the Lower Triassic began with marine transgressions and ended with regressions (Ch 15), which may have been worldwide.

## DENDROCHRONOLOGY

Lara A, Villalba R. 1993. A 3620-year temperature record from *Fitzroya cupressoides* tree rings in southern South America. *Science* 260:1104-1106.

**Summary.** The alerce tree, *Fitzroya cupressoides*, is a member of the cypress family (Cupressaceae). It is the second-longest growing tree species known. Tree-ring samples were taken from alerce trees in southern Chile. Forty-three of 96 samples were successfully cross-dated. The oldest tree was estimated to be 3613 years old when cut down in 1975, as determined by cross-dating. Only four cross-dated samples were found for the period before 875 B.C., but the remainder of the tree-ring chronology is sufficiently supported to justify inferences about the climate where the tree was growing. Climatic inferences based on the tree-ring widths do not correlate well with historical records maintained since 1910. This disagreement may be partly due to local differences between the area where the trees grew and the areas where climate records were collected. Matching is better for warm summers than for cold summers.

**Comment.** Such events as the Little Ice Age are not reflected in these tree rings. There is no indication of a recent continuous warming trend.

## EVOLUTION

Block BA, Finnerty JR, Stewart AFR, Kidd J. 1993. Evolution of endothermy in fish: mapping physiological traits on a molecular phylogeny. *Science* 260:210-214.

*Summary.* Endothermy, the ability to warm the body through metabolic activity, is absent in most fish, but is present in two families of sharks and three families of bony fish. The bony fish with endothermy are all members of the suborder Scombroidei, and include tunas and two families of billfishes, but not bonitos. The question addressed here is whether endothermy is convergent in these three families, or whether it was inherited from a common ancestor. Tunas achieve endothermy through high metabolic rates and low rates of body heat loss. Billfishes possess a heat-producing organ that warms only the brain and retina. The butterfly mackerel also warms only the brain and retina, but the anatomical details differ from the billfishes. The authors compare the distribution of endothermy with a molecular phylogeny based on the DNA sequence of the mitochondrial gene for cytochrome b. Their comparison indicates that endothermy occurs independently in each of the three groups of fish, and is not inherited from a common ancestor.

## GENETICS

Dessauer HC, Gee GF, Rogers JS. 1992. Allozyme evidence for crane systematics and polymorphisms within populations of sandhill, sarus, Siberian and whooping cranes. *Molecular Phylogenetics and Evolution* 1:279-288.

*Summary.* There are 15 living species of cranes, all of which were sampled for this study. Based on protein electrophoresis, the two species of African crowned cranes are distinct from the remaining species, which are themselves divided into two groups. The "sandhill group" consists of seven species, and is distributed across the Old World, with the sandhill crane reaching North America. The "whooper group" consists of six species which are all restricted to the northern continents.

Single species diversity was also analyzed. A significant result was the discovery that genetic diversity among whooping cranes was surprisingly high, similar to that for the six other species with which it

was compared. This is contrary to expectations of genetic loss due to a population bottleneck of some 15 individuals in the 1940s.

**Comment.** The possibility should be explored that some mechanism exists for rapidly restoring genetic variability after population bottlenecks.

Hatfield D, Diamond A. 1993. UGA: a split personality in the universal genetic code. *Trends in Genetics* 9:69-70.

**Summary.** UGA, a three-base unit for the genetic code system, has the largest variation of uses in the genetic code. It most often is a stop codon, but it codes for the amino-acid tryptophan in mitochondria and *Mycoplasma* (a small bacterial type of organism), inefficiently so in *B. subtilis* (a bacterium), and codes for cysteine in a species of *Euplotes* (a protozoan). It can also function as a selenocysteine codon in species from the following groups: bacteria, fungi, protists, higher plants, and mammals. Thus UGA should be considered to function both as a stop signal and as a part of the universal genetic code for a 21st amino acid, selenocysteine.

Ohta T, Basten CJ. 1992. Gene conversion generates hypervariability at the variable regions of kallikreins and their inhibitors. *Molecular Phylogenetics and Evolution* 1:87-90.

**Summary.** Kallikreins are a group of serine proteases found in mammals. A family of genes codes for these enzymes. DNA sequences in the active region of the proteins' sites are more variable than in neutral sites between genes, suggesting that some mechanism is causing a higher rate of mutation in the region coding for the active site. Kallikrein genes are believed to engage in frequent exon shuffling, but gene conversion seems to be the mechanism involved here. Gene conversion occurs when one sequence is copied to match a second, usually similar, sequence. Some gene copies may act as reservoirs of genetic variability by retaining alternative sequences which may be substituted into a transcribed gene. Thus, gene conversion may be an important source of genetic variability.

Thompson CB. 1992. Creation of immunoglobulin diversity by intrachromosomal gene conversion. *Trends in Genetics* 8:416-422.

**Summary.** Antibody molecules are an important part of body defenses against disease. Each antibody molecule is made of various "chains" that include three parts: a variable region (V), a constant region (C) and a joining region (J). These three parts are coded for by

different DNA sequences, which are spliced together. In humans, immunoglobulin (Ig) genes undergo somatic recombination during B cell development, in which different combinations of V, J and C regions are produced, each forming a distinct antibody molecule. Up to  $10^{11}$  different combinations may be produced. However, a different process occurs in rabbits and many birds, in which pseudogenes play a key role in creating antibody diversity in B cells by gene conversion (copying of the DNA sequence from one gene into another). In the chicken, the 5' to 3' gene sequence is: about 25 psi-V pseudogenes, followed by single V, J and C regions. The single V and J regions are spliced together, followed by gene conversion of the V region from one of the upstream psi-V pseudogenes.

*Comment.* Pseudogenes are commonly thought to be non-functional, but this may simply indicate our lack of understanding of their function.

## GEOLOGY

Raup DM, Jablonski D. 1993. Geography of end-Cretaceous marine bivalve extinctions. *Science* 260:971-973.

*Summary.* Many Cretaceous fossils do not have corresponding fossils in Tertiary sediments. This disappearance is generally attributed to an extraterrestrial impact that wiped out much of Earth's biota, including dinosaurs. For bivalve mollusks, 63% of Cretaceous genera are not found in Tertiary sediments. Previous studies have suggested that the degree of extinction was greatest in tropical latitudes west of 30° W paleolongitude, which includes the area of the Chicxulub Crater on the Yucatan Peninsula of Mexico. Raup and Jablonski report that this geographical trend is due to the rudists, an extinct group of bivalve mollusks.

*Comment.* When the rudists are removed from the analysis, the extinction rate appears to be rather uniform worldwide. Accordingly there seems to be no evidence for a local cause of the end-Cretaceous extinction.

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 (major granitic masses) and volcanic rocks are usually interpreted as magmas that cooled and crystallized when they came into contact



with 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 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."

*Comment.* This contamination has important implications for the interpretation of radiometric dates with respect to magma crystallization.

## IMPACT CATASTROPHES

Gratz AJ, Nellis WJ, Hinsey NA. 1992. Laboratory simulation of explosive volcanic loading and implications for the cause of the K/T boundary. *Geophysical Research Letters* 19:1391-1394.

*Summary.* Planar deformation features found in particles associated with craters are interpreted as evidence of extraterrestrial impact. Explosive volcanism appears to be incapable of producing these features. The largest historical volcanic event was Tambora, which released about  $10^{20}$  joules of energy and created pressures of about 1.5 GPa. Impact of an asteroid greater than 10 km diameter would release at least  $10^{25}$  joules and generate peak shock stresses in excess of 100 GPa. Laboratory simulations subjecting granite samples at 600°C to 0.9 and 1.3 GPa did not produce any planar deformation features. The only available explanation for these features is a large extraterrestrial impact.

Gudlaugsson ST. 1993. Large impact crater in the Barents Sea. *Geology* 21:291-294.

*Summary.* A crater discovered on the sea floor north of Scandinavia is thought to be an impact crater. Known as the Mjølnir structure, the crater is 39 km in diameter, probably produced by an impactor from 0.7 to 2.5 km in diameter. The stratigraphic position of the crater is Upper

Jurassic to Lower Cretaceous. Only 18 craters larger than 30 km in diameter are known. This crater is one of the best preserved large impact craters, and is situated in a relatively complete epicontinental seaway sedimentary series extending from Carboniferous to Cretaceous.

Oberbeck VR, Marshall JR, Aggarwal H. 1993. Impacts, tillites, and the breakup of Gondwanaland. *Journal of Geology* 101:1-19.

**Summary.** Many extraterrestrial impact craters have been identified on the earth's surface, and more such identifications are expected. A study of the 26-km Ries Crater in Germany revealed that the impact stripped the local ground surface, producing striations and polished surfaces, with dislodged blocks as large as 200 m in diameter. Accumulated deposits increase with distance from the crater rim, reaching a maximum thickness of 200 m. Impact deposits formed in water may produce dropstones and multiple turbidite layers. Tillites and diamictites, classically interpreted as produced by glaciers, may also be produced by impacts.

Some features of tillites are problematic for a glacial origin. Known glacial deposits do not exceed about 300 m in depth, whereas some tillite deposits may reach 3000 m in depth. Tillites often are found among deposits that appear to be from warm environments. Since impacts can produce similar features, many tillites should be reinterpreted.

The effects of impacts on continental targets are also considered by Oberbeck et al. Extensive tillite deposits are found stratigraphically lower than some of the largest flood basalts, and geographically associated with them. These flood basalts (Parana, Karoo and Siberian) were followed by continental breakup. Flood basalts seem to appear abruptly within plates, without known cause. A mechanism is needed to explain continental breakup.

**Comment.** The current model of mantle flow has some serious shortcomings. Extraterrestrial impacts may be the cause of the fragmentation of Gondwana.

Robin E, Froget L, Jehanno C, Rocchia R. 1993. Evidence for a K/T impact event in the Pacific Ocean. *Nature* 363:615-617.

**Summary.** Spinel-containing spherules, believed caused by extraterrestrial impact, have been recovered from Cretaceous/Tertiary boundary sediments at several sites on the sea floor of the Pacific Ocean. Chemical analysis suggests the spherules are composed of

almost pure meteoritic material. This evidence and their location suggests a source other than the Yucatan peninsula, which is thought to be the site of a major end-Cretaceous extraterrestrial impact. The authors postulate a Pacific Ocean impact of an asteroid 2 km in diameter to explain the presence of the ocean floor spherules. The worldwide evidence for extraterrestrial impact may have been the result of many smaller impacts rather than one or two large ones.

## MAMMALOGY

Dung VV, Giao PM, Chinh NN, Tuoc D, Arctander P, MacKinnon J. 1993. A new species of living bovid from Vietnam. *Nature* 363:443-445.

**Summary.** A new species of living antelope has been discovered in forests of Vietnam. This is the first new species of large mammal to be discovered since the Chaco peccary was found in the 1970s. A new genus, *Pseudoryx*, has been erected to classify the species. Mitochondrial DNA sequences indicate the new species may not be closely related to any known bovid. Unfortunately, its distribution lies in an area raged by war, and its survival is precarious.

## MOLECULAR EVOLUTION

Bradley D, Carpenter R, Sommer H, Hartley N, Coen E. 1993. Complementary floral homeotic phenotypes result from opposite orientations of a transposon at the plena locus of *Antirrhinum*. *Cell* 72:85-95.

**Summary.** Snapdragons may undergo a mutation (plena) in which carpels develop in place of the petals and sepals. Another mutation (ovulata) is known in which sepals and petals develop in place of the pistils and stamens. Study of these two mutations reveal that both mutations are caused by insertion of a transposon, called Tam3. Without Tam3, the flower develops normally. The normal gene appears to be made of nine exons, each separated by an intron. The Tam3 transposon inserts in the second intron, between exons 2 and 3. When Tam3 inserts in the same orientation as the normal gene, the result is the plena mutation. When Tam3 inserts in the reverse orientation, the ovulata mutation results.

**Comment.** While neither of these mutations is likely to endure in a population, they do illustrate the sensitivity of normal development to the effects of transposable elements.

Hagemann AT, Craig NL. 1993. Tn7 transposition creates a hotspot for homologous recombination at the transposon donor site. *Genetics* 133:9-16.

**Summary.** The *lacZ* gene in the common bacterium, *E. coli*, may have a transposable element (Tn7) inserted, resulting in loss of lactase production. When Tn7 is stimulated to transpose (move to a new location), the donor sequence is left with a gap, and the host sequence receives a Tn7 transposon. Repair of the broken donor chromosome is accompanied by restoration of the Tn7 transposon sequence. This is accomplished by homologous recombination and gene conversion, in which the Tn7 sequence is restored by homologous recombination with a sister chromosome. (Rapidly growing cells of *E. coli* contain more than 1 copy of the chromosome.) Thus Tn7 transposition, normally non-replicative, may be effectively replicative. If an ectopic chromosome lacking Tn7 is available, it may be used as a template for gene conversion. If this occurs, lactase activity is restored. The frequency of homologous recombination of the transposon may be increased 10-fold when the rate of transposition of Tn7 is stimulated.

## MOLECULAR SYSTEMATICS

Chevret P, Denys C, Jaeger J-J, Michaux J, Catzeflis FM. 1993. Molecular evidence that the spiny mouse (*Acomys*) is more closely related to gerbils (Gerbillinae) than to true mice (Murinae). *Proceedings of the National Academy of Sciences (USA)* 90:3433-3436.

**Summary.** Dental morphology has played a central role in many hypotheses of mammalian evolution. A particular molar pattern has been used to support the monophyly of mice of the subfamily Murinae. This molar pattern is present in mice of the genus *Acomys*, and they have accordingly been classified in Murinae. However, immunological data previously reported, and DNA-DNA hybridization data reported here, indicate that *Acomys* and two African genera form a monophyletic group which is actually more similar to the subfamily Gerbillinae than to Murinae. Thus the unique dental pattern thought to unite the subfamily Murinae is interpreted as convergent in these three genera.

**Comment.** Such findings illustrate the frequent disagreement of molecular and morphological data in phylogenetic hypotheses, and do not bode well for phylogenetic hypotheses of mammalian relationships based almost entirely on dentition.

Dowling TE, DeMarias BD. 1993. Evolutionary significance of introgressive hybridization in cyprinid fishes. *Nature* 362:444-446.

**Summary.** The fish family Cyprinidae contains several species in the genus *Gila*, often known as chubs. Two different clustering methods gave similar phylogenies for several *Gila* species using genetic distances derived from protein electrophoresis. Likewise, two clustering methods gave similar phylogenies using mitochondrial DNA restriction sites. However, phylogenies based on the two data are in poor agreement. The pattern of discordance suggests that hybridization among different species has occurred in the past. This hybridization has produced discordance in phylogenies, and has contributed to the production of new varieties. Hybridization seems to be an important mechanism increasing the number of species within some groups.

Graur D. 1993. Molecular phylogeny and the higher classification of eutherian mammals. *Trends in Ecology and Evolution* 8:141-147.

**Summary.** A primary goal of phylogenetic systematics is to produce a classification that is based totally on monophyletic groups. (A monophyletic group consists of an ancestor and all its descendants.) Various groupings of mammal orders have been proposed, such as “Glires” (Rodentia + Lagomorpha) and “Archonta” (typically Primates + Dermoptera + Scandentia). However, these groupings have received limited support, and various contradictory alternatives have been proposed.

Molecular data is now having a significant impact on classification, resulting in some new ideas and new problems. Molecular phylogenies sometimes share few similarities with morphological phylogenies. For example, perissodactyls (horses and allies) and artiodactyls (cattle and allies) have traditionally been grouped together on morphological grounds. Molecular comparisons group artiodactyls with whales, while perissodactyls are grouped with hyraxes and elephants. Furthermore, whales do not show up as a sister group to artiodactyls, but nest within artiodactyls as a sister group to ruminants. In other words, whales appear more closely related to cattle than pigs or camels do. If so, then either Artiodactyla must be redefined to include whales, or Cetacea must be retained as an order, and the artiodactyls separated into probably three orders: Ruminantia, Tylopoda, and Suiformes. Another problem arises with Rodentia, which appears to be paraphyletic (does not include all the descendants of an ancestor) with respect to other groups in some molecular phylogenies. One solution to this is to

dismember Rodentia. into several orders, such as Myomorpha, Hystricomorpha and Ctenodactyla.

**Comment.** Although molecular phylogenies tend to contain many inconsistencies and contradictions, they have had the beneficial effect of forcing a reappraisal of mammalian relationships. It remains to be seen what the result will be.

Martin W, Lydiate D, Brinkmann H, Forkmann G, Saedler H, Cerff R. 1993. Molecular phylogenies in angiosperm evolution. *Molecular Biology and Evolution* 10:140-162.

**Summary.** DNA sequences for glyceraldehyde-3-phosphate dehydrogenase were compared from a bryophyte, a gymnosperm and three angiosperms, along with other published species, totaling 19 species. Results indicate the deepest angiosperm dichotomy is between monocots and dicots, not one between magnoliads or other dicot groups and the others. On fossil evidence, the bryophyte spermatophyte dichotomy is dated at about 450 Ma. Application of the molecular-clock hypothesis yields dates of about 330 Ma for the conifer-angiosperm dichotomy, and about 300 Ma for the monocot-dicot divergence.

**Comment.** Both dates are far older than the conventional date of about 130 Ma for the earliest unequivocal angiosperm. The origin of angiosperms, Darwin's "abominable mystery," is still unsolved.

Melnick DJ, Hoelzer GA, Absher R, Ashley MV. 1993. mtDNA diversity in rhesus monkeys reveals overestimates of divergence time and paraphyly with neighboring species. *Molecular Biology and Evolution* 10:282-295.

**Summary.** Rhesus monkeys have a wide geographic distribution, ranging from Pakistan to the Pacific coast of China, and occupying a variety of habitats. Despite the ecological heterogeneity, the degree of morphological diversity among rhesus monkeys is no greater than normal for a single species. Nuclear DNA sequences link eastern and western rhesus monkeys, while mitochondrial DNA sequences link eastern continental rhesus monkeys with island species on Japan and Taiwan. This is explained as follows: glaciation in the center of the habitat range separated eastern and western populations of rhesus monkeys. During this time, lowered sea levels permitted eastern rhesus monkeys to reach Japan and Taiwan. Thus eastern rhesus monkeys and insular species share a more recent ancestry than eastern and western rhesus populations, as indicated by mitochondrial DNA similarities. Later, the insular populations became isolated as the glaciers

melted. Contact was re-established between eastern and western rhesus populations. Since dispersal is usually accomplished by males, nuclear DNA was exchanged but mitochondrial DNA was not exchanged between the eastern and western rhesus populations, as reflected in nuclear DNA similarities.

**Comment.** Mitochondrial DNA diversity is high in rhesus monkeys. If only a single individual had been studied, the putative history described above could not have been discerned.

Milinkovitch MC, Orti G, Meyer A. 1993. Revised phylogeny of whales suggested by mitochondrial ribosomal DNA sequences. *Nature* 361:346-348.

**Summary.** Modern whales are classified into two suborders, toothed whales (Odontoceti) and baleen whales (Mysticeti). Toothed whales have a fossil record from Eocene to Recent, while mysticete whales are found from Oligocene to Recent. Comparison of mitochondrial DNA sequences for 12S and 16S RNA was done for 16 cetacean species. Most of these species were toothed, but one family of baleen whales was included.

**Comment.** According to the results, sperm whales are more similar to baleen whales than to other toothed whales. This result is in conflict with classification based on morphological grounds, and does not seem to correlate well with the fossil record.

Sherman DR, Kloek AP, Krishnan BR, Guinn B, Goldberg DE. 1992. *Ascaris* hemoglobin gene: plant-like structure reflects the ancestral globin gene. *Proceedings of the National Academy of Sciences (USA)* 89:11696-11700.

**Summary.** Animal globin genes have three exons and two introns, while plant globin genes have a third intron, dividing one of the exons in two. The ancestral globin gene has been predicted to have had three introns. The parasitic roundworm *Ascaris* globin gene has three introns. *Ascaris* and plants also share two other features not found in other multicellular animals: the glyoxylate cycle and de novo synthesis of polyunsaturated fatty acids. One explanation for this anomalous pattern is that *Ascaris* retains the primitive traits. An alternative explanation is that *Ascaris* and other multicellular groups are unrelated.

## ORIGIN OF LIFE

Kasting JF, Egglar DH, Raeburn SP. 1993. Mantle redox evolution and the oxidation state of the Archean atmosphere. *Journal of Geology* 101:245-257.

**Summary.** The composition of the primordial atmosphere is an important concern for development of a naturalistic explanation for the origin of life. An oxidizing atmosphere would favor chemical destruction of biomolecules. Current models postulate a primordial atmosphere rich in carbon dioxide, but such an atmosphere would be too oxidizing for efficient production of amino acids and other molecules needed for life. The authors propose a model in which the oxidation state of the mantle has changed over time. According to their model, the mantle was originally more reduced than at present. The loss from the mantle of reduced volcanic gases, combined with the gain by subduction of oxidized sea floor sediments, would result in a steadily increasing oxidation state for the mantle. Once the atmosphere became oxidized, the oxidation state would remain about the same, because atmospheric hydrogen would be oxidized to water rather than lost to space. Oxidation of the sources of volcanic gases would chemically balance the gain of oxidized sediments. This model is proposed to explain why Archean (lower Precambrian) photosynthetic activity was not associated with an oxidizing atmosphere. The authors admit that the evidence is mixed for the oxidation state of the Archean mantle.

**Comment.** Although the knowledge gained from study of the mantle may be useful, naturalistic attempts to explain the origin of life continue to be unsuccessful.

Schwartz AW, de Graaf RM. 1993. The prebiotic synthesis of carbohydrates: a reassessment. *Journal of Molecular Evolution* 36:101-106.

**Summary.** One of the major difficulties with origin of life scenarios is a plausible source of sugar, particularly the ribose needed for nucleic acid synthesis. The formose reaction involves the polymerization of formaldehyde to form sugars in the presence of a base catalyst. This reaction was studied to see whether it was a plausible prebiotic source of sugar. The formose reaction does occur in abiotic conditions, with certain minerals acting as catalysts in near-neutral pH solutions. However, the reaction specifically produces the sugar pentaerythritol, which has no known biological significance. The formose reaction is



not a plausible prebiotic source of ribose, nor is any other plausible prebiotic source known.

Widdel F, Schnell S, Heising S, Ehrenreich A, Assmus B, Schink B. 1993. Ferrous iron oxidation by anoxygenic phototrophic bacteria. *Nature* 362:834-836.

**Summary.** Precambrian (Archean and lower Proterozoic) banded iron formations (BIFs) are alternating layers of iron-rich and silica rich sediments that may cover large areas. Their origin is something of an enigma. It was thought that oxygen was required to oxidize ferrous iron (iron 2) to ferric iron (iron 3). This presented a problem for the standard model of earth history, because it is thought that oxygen was not present in the atmosphere in significant quantities during the period of Archean deposition. Newly discovered bacteria are now known to be able to oxidize ferrous iron to ferric iron, and reduce carbon dioxide for biological use, without the presence of oxygen.

**Comment.** Although the new discovery does not demonstrate the origin of banded iron formations, it does open up a new area for discussion.

## PALEONTOLOGY

Brigg DEG, Kear AJ. 1993. Fossilization of soft tissue in the laboratory. *Science* 259:1439-1442.

**Summary.** Most fossils occur as bones, shells, or plant debris. However, fossils are sometimes found with muscles and other soft tissues preserved. Preservation of muscle tissue usually involves calcium phosphate. Experiments with two species of crustaceans showed that mineralization of soft tissue is inhibited by the presence of oxygen. Normal decay processes rapidly reduce the oxygen concentration in the fluid surrounding the crustaceans, permitting tissue mineralization unless reoxygenation is permitted. At least partial mineralization of muscle tissue occurred in 4-8 weeks in the majority of those specimens in which oxygen remained depleted. The source of the calcium phosphate can be the specimen itself, but microbial action is involved in its deposition within the muscle tissue. Mineralization was initiated within 2 weeks. Results indicate that specific conditions are required in order for soft tissue to become mineralized.

Budd AF. 1993. Faunal turnover in Neogene to Recent Caribbean reef coral and regional environmental change. GSA Abstracts with Program (North-Central Section) 25(3):9.

**Summary.** More than 75% of all species found in uppermost Miocene or lower Pliocene Caribbean reef deposits became extinct by the beginning of the Pleistocene. After the drastic faunal change at the Pliocene-Pleistocene transition, the total number of species was about the same as before.

**Comment.** The coral reef fauna has been stable throughout the Pleistocene. This seems difficult to explain with the standard model of Earth history in which dramatic climatic changes occurred throughout the Pleistocene. One would expect considerable faunal changes in response to Pleistocene climatic changes.

Dilly PN. 1993. *Cephalodiscus graptolitoides* sp. nov. a probable extant graptolite. Journal of Zoology, London 229:69-78.

**Summary.** Graptolites are somewhat enigmatic fossils, at various times considered to be plants or animals of uncertain affinities. A close affinity with pterobranchs in the phylum Hemichordata was suggested in 1948. This interpretation is greatly strengthened by the recent discovery of a living graptolite-like organism.

The new species was discovered near the island of New Caledonia in water 253 m deep. It has been assigned to the genus *Cephalodiscus*, a pterobranch genus of 16 described species. The new species is a sessile encrusting form, with separate sacs each containing a single adult zooid. The critical feature of the new species that indicates its relationship with graptolites is the presence of long slender spines on the surface of the colony. Each spine appears to be a feeding station alternately shared by several zooids. The spine is interpreted as being homologous to the nema of graptolites.

**Comment.** If this interpretation is correct, this species can truly be considered a living fossil, because graptolites were thought to have been extinct since the Carboniferous.

Martin RD. 1993. Primate origins: plugging the gaps. Nature 363:223-233.

**Summary.** Modern primates are generally classified into two major groups. Lemurs, galagos and their allies form one group, while monkeys, apes and humans form the other. Tarsiers are usually placed

closer to monkeys than to lemurs, with some uncertainty. These two major living groups have been associated with different putative ancestors in the fossil record. Lemurs and their allies have been considered to be derived from the extinct Adapidae, with the tarsiers and probably monkeys derived from extinct Omomyidae. The extinct Plesiadapiformes were thought to be the most primitive of all primates. This picture was based largely on interpretations of the evolution of mammal teeth. New fossil discoveries have added other skeletal parts, greatly revising the interpretation of relationships.

Plesiadapiformes are now thought not to be primates at all, and their affinities are obscure. The extinct Adapidae and Omomyidae are now seen as evolutionary dead-ends. Diverse monkey-like fossils have been discovered in Eocene deposits, the stratigraphic level in which the Adapidae and Omomyidae fossils are found.

**Comment.** There are no fossils available as plausible ancestors of the primates, leaving the primate tree without a trunk.

Thewissen JGM, Hassain ST. 1993. Origin of underwater hearing in whales. *Nature* 361:444-445.

**Summary.** Fossil incus bones of the inner ear of the archeocete *Pakicetus* have been recovered and are described here. Whales have ear bones that differ from those of other mammals. Sound is transmitted through the jaw in modern whales, whereas in terrestrial mammals sound is transmitted through the external auditory meatus. *Pakicetus* appears to have lacked the jaw structure for sound transmission, and thus must have used a system similar to that of land mammals.

The whale incus has a greatly inflated body and crus longum, and the joint between the malleus and incus faces rostrally. In terrestrial mammals, the incus is more slender, the crus longum is longer, and the joint between the malleus and incus faces rostromedially. *Pakicetus* is the only whale known with the intermediate condition of an inflated incus with elongated crus longum (found also in some pinnipeds), and the joint between the malleus and incus partially rotated. The morphology of the ear of *Pakicetus* and the shallowness of the “river” in which the fossil was found is said to suggest that it might not have been fully aquatic.

Vartanyan SL, Garutt VE, Sher AV. 1993. Holocene dwarf mammoths from Wrangel Island in the Siberian Arctic. *Nature* 362:337-340.

Fossil tusks of woolly mammoths have been found that give radiocarbon ages of less than 4,000 years. This is less than half the radiocarbon age of the youngest previously known woolly mammoths. The fossils were found on Wrangel Island, which lies to the north of eastern Siberia, at 180 degrees longitude. The youngest fossil teeth are smaller than average for the species, which is explained as a case of dwarfing on islands. Survival of this population long after the rest of the species became extinct seems to favor the human overkill hypothesis over the climate-change hypothesis of Pleistocene megafaunal extinction.

### **PALEONTOLOGY: FOSSIL BIRDS**

Altangerel P, Norell MA, Chiappe LM, Clark JM. 1993. Flightless bird from the Cretaceous of Mongolia. *Nature* 362:623-627.

**Summary.** A bird-like fossil has been recovered from the Upper Cretaceous Nemegt Formation in Mongolia. Nearly all parts of the skeleton were present. The fossil appears to be intermediate between *Archaeopteryx* and living birds. This conclusion is supported by five characters, and contradicted by two characters. Six characters of birds are lacking. The fossil has a long reptilian tail, and the forelimb is strongly built, with a single stout claw. The organism was clearly unable to fly, although the sternum is keeled. The claw appears to be potentially useful for digging, but the hindlimbs do not appear to fit with a burrowing lifestyle.

**Comment.** The fossil is in the wrong stratigraphic position to be interpreted as ancestral to modern birds, but illustrates the previous existence of combinations of characters that are no longer found together.

Feduccia A. 1993. Evidence from claw geometry indicating arboreal habits of *Archaeopteryx*. *Science* 259:790-793.

**Summary.** The arc of curvature of a bird's claw varies according to whether it lives on the ground, perches in trees, or climbs trees. *Archaeopteryx* has claws on both the feet and wings. The claws on the feet have the curvature typical of perching birds, while the wing claws have curvature typical of trunk-climbing birds. Based on this and other evidence, the conclusion presented is that *Archaeopteryx* lived in trees, and probably could fly.

Speakman JR. 1993. Flight capabilities in *Archaeopteryx*. *Evolution* 47:336-340.

**Summary.** Living birds that can take off from the ground have at least 16% of their body mass as deltoid and pectoral muscles. It appears that birds with less than this proportion of flight muscle are unable to spring directly into flight from the ground. *Archaeopteryx* is estimated to have had only 9% of its body mass as flight muscle. However, it has been suggested that *Archaeopteryx* might have been able to fly anyway, because it may have had reptilian tissue, which produces power with greater efficiency. Speakman challenges this suggestion by pointing out that reptilian tissue is not really more efficient, it merely can briefly produce more power by using anaerobic metabolism. Previous estimates of power production by reptiles and birds used different methods, which are not equivalent. Applying the same method to both birds and reptiles shows that power production of reptiles is not as much greater than birds as had been previously calculated. The conclusion is that *Archaeopteryx* could not take flight directly from the ground.

## PALEONTOLOGY: DINOSAURS

Carpenter K. 1992. Behavior of hadrosaurs as interpreted from footprints in the “Mesaverde” Group (Campanian) of Colorado, Utah, and Wyoming. *Contributions to Geology, University of Wyoming* 29:81-96.

**Summary.** Dinosaur footprints in coal mines near Price, Utah correlate with the lower Two Medicine Formation of Montana. Grand Mesa (Colorado) footprints correlate with the upper Two Medicine and Judith Formations. Dinosaur tracks from Rock Springs, Wyoming, correlate with the Horseshoe Canyon Formation of Alberta. In both Price and Grand Mesa, the majority of the footprints were headed south. Trackways are uncommon. The explanation given for the footprints is that the hadrosaurs migrated seasonally, occupying the swamps during the dry season in order to find food and water. Hatching is inferred to have occurred at the beginning of the rainy season. Hadrosaurs are inferred to have been terrestrial most of the year.

**Comment.** Inferences of dinosaur behavior from footprints depend on whether one assumes the behavior was normal or whether the animals were under stress at the time. In a catastrophic model, one cannot assume the footprints or nest relationships represent the normal behavior of the species.

Nadon GC. 1993. The association of anastomosed fluvial deposits and dinosaur tracks, eggs and nests: implications for the interpretation of floodplain environments and a possible survival strategy for ornithopods. *Palaios* 8:31-44.

**Summary.** The St. Mary River Formation is a nonmarine unit, 200-300 m in thickness, in southeastern Alberta and northwestern Montana. It contains numerous dinosaur tracks and eggshell fragments, amphibians, fish scales, freshwater mollusks and plant fossils. Only one articulated skeleton has been found, a small *Champsosaurus*. The depositional environment is interpreted as a floodplain with anastomosing streams and shallow, probably short-lived, lakes. Most of the tracks are of herbivores, but some tracks of carnivorous theropods have also been found. Similar depositional environments are inferred for dinosaur trackways in the Gething Formation in northeastern British Columbia, the Two Medicine Formation in western Montana, and several other sites in North America, one in South Africa and two in France.

Various interpretations of hadrosaur habitat have been proposed, ranging from aquatic to fully terrestrial. Nadon infers a marshy habitat. The possibility that the inferred depositional environment might not represent the normal habitat for these dinosaurs should be considered.

Rogers RR, Swisher (III) CC, Sereno PC, Monetta AM, Forster CA, Martinez RN. 1993. The Ischigualasto tetrapod assemblage (Late Triassic, Argentina) and  $^{40}\text{Ar}/^{39}\text{Ar}$  dating of dinosaur origins. *Science* 260:794-797.

**Summary.** The stratigraphically lowest dinosaur fossils are found in the part of the Triassic known as the Carnian. They appear at this same point in North America, South America, India and Africa. The Ischigualasto Formation of Argentina is one of the areas from which Carnian dinosaur fossils are known. Three genera of dinosaurs are found here; two genera are saurischians and one is ornithischian, indicating a diversity at first appearance of the dinosaurs.

## 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.*

## MYSTERIOUS SOLUTIONS

BLUEPRINTS: SOLVING THE MYSTERY OF EVOLUTION. M.A. Edey and D.C. Johanson. 1989. Little, Brown and Co., Boston, Massachusetts. 418 p. Cloth, \$19.45.

*Reviewed by L. James Gibson, Geoscience Research Institute*

Edey and Johanson trace the history of the modern development of evolutionary theory, starting with Linnaeus and others (one chapter) and continuing to the present. Darwin and Wallace receive the usual accolades for straight thinking (three chapters), but the major thrust of the book (eleven chapters) is a history of the discoveries leading to the understanding of DNA as the material of heredity. The book concludes with a discussion of Johanson's specialty, paleoanthropology (one chapter), and a warning that human intelligence seems to be creating more problems than it can solve (one chapter). Throughout the book, the reader is assured that evolution is soundly based on scientific evidence, which presumably cannot be interpreted in any other cogent manner.

Creationists are attacked throughout the book. In at least one place (p 50), creationism seems to be equated with belief in fixity of species, which reflects a serious misunderstanding of creationism. Creationists are also accused of ignoring the data (p 2-4), denying the "Central Dogma" that proteins are made from information stored in DNA (p 274-275), and distorting God's character (p 291).

Although creationists are human, and prone to make mistakes, the objections raised by Edey and Johanson seem off the mark. The accusation that creationists deny the relationship between DNA and proteins is unworthy of consideration. Two points are of greater significance, both raised on p 291. The first is that if God did something, there is no point in studying it scientifically. Many scientists have felt that in studying science they were "thinking God's thoughts after Him."

Perhaps we can learn something about the Creator by studying the creation, especially with consideration of the information given more clearly in the Scriptures concerning the Creator and His relationship to nature. The second, more significant, point is the assertion that creationists have an ugly view of God's character.

To this reviewer, the implications that one's view of origins have for God's character is a topic that an evolutionist would want to avoid. Although creationists might make some mistakes in interpreting His character, these mistakes are not inherent in the creation theory. The theory of evolution implies that God is probably not involved in creation. If God is involved, then competition and death are His chosen method of creation, and He, not man, is responsible for death. These implications are incompatible with the life and teachings of Jesus Christ (John 11:25, Luke 12:6) and the apostles (Romans 5:12), and impugn the character of God. This consideration provides a sufficient reason for any Christian to reject evolution.

Two fatal flaws of naturalistic evolutionary theory are briefly mentioned by the authors, seemingly without realizing their seriousness. The resistance of species to change beyond a certain point is well known. Sheep may vary, but they remain sheep (p 125). Similar statements could be made of every species investigated by science. Science is able to test whether species have the capacity to change. The test has been performed countless times, and the result has always been that species can change in modest amounts, but always within limits. When science demonstrates that species can change in ways that produce new types of organisms, creationists will take note of it. In the meantime, creation provides a plausible explanation for the origin of the diversity of living organisms. The second flaw in the argument presented in the book is the failure of science to explain the origin of life. The hypercycle theory of Eigen may be the best naturalistic model available at present (p 295), but it is not convincing. Creationists feel that the best model available is not naturalistic at all. Creation is simply a better explanation for the origin of life and for the origin of higher taxonomic categories. Until science can demonstrate these propositions to be wrong, creationism will thrive.

Overall, the book presents some interesting points of discussion, but they are discussed without an adequate understanding of creationism. Despite the title, evolution does not appear any more plausible after reading the book.



## LITERATURE REVIEWS

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### DUSTY EVIDENCE

MOONDUST AND THE AGE OF THE SOLAR SYSTEM. 1993. Andrew A. Snelling and David E. Rush. *Creation Ex Nihilo Technical Journal* 7(1):2-42.

*Reviewed by R. H. Brown, Yucaipa, California*

The depth of dust on the moon has been featured in creationist literature as scientific evidence supporting placement of the origin of the Solar System (and the entire physical universe) less than 10,000 years ago. There have been claims by creationists that most astronomers and scientists expected a deep dust layer that presumably collected over millions of years and would hazard a spacecraft landing on the moon.

Snelling and Rush present the results of a seven-year investigation of both creationist literature and the professional scientific literature related to accumulation of the lunar regolith (surface layer of unconsolidated material). Both authors are strongly identified with the most conservative segment of biblical creationism. Andrew Snelling holds a doctorate in geology, is employed full-time by the Creation Science Foundation, Ltd., of Australia, is the editor of *Creation Ex Nihilo Technical Journal*, and contributes to the companion publication *Creation Ex Nihilo*. David Rush has a master's degree in physics, has been employed by the Institute for Creation Research, and is a public-school science teacher in California. They have produced an exhaustive, thoroughly professional treatment of cosmic dust accumulation on the moon.

Many creationists will be disillusioned, or at least disturbed, by the technical and historical details Snelling and Rush have made readily accessible. These authors forthrightly state that

*... the amount of meteoritic dust and meteorite debris in the lunar regolith and surface dust layer, even taking into account*

*the postulated early [more] intense meteorite and meteoritic dust bombardment, does not contradict the evolutionists' multi-billion year time scale (while not proving it)... creationists should not continue to use the dust on the moon as evidence against an old age for the moon and the solar system (Abstract, p 3).*

They further state that “creationists cannot say or imply, as some have, that most astronomers and scientists expected a deep dust layer” on the moon (p 30). Contrary to claims made by some creationist writers, Snelling and Rush document that “the data had already convinced most scientists before the Apollo moon landings that very little dust would be found on the moon” (p 37).

Valid estimates of the meteoritic dust influx to the earth in tons/year, as obtained by Snelling and Rush from the professional literature, range from 450 to 460,000. Estimates for the moon range from 4000 to 19,900. Using 10,000 tons/year as a representative estimate, Snelling and Rush note that about one billion years would be required to accumulate a 2 cm thick dust layer over the lunar surface. The Apollo astronauts reported lunar surface dust thickness ranging between 0.3 cm and 7.6 cm. So Snelling and Rush can say that “even with a meteoritic dust influx rate of 300 times the present figure, we can still comfortably account for the quantity of meteoritic dust found in the lunar regolith and the loose surface layer over the evolutionists’ timescale” (p 38). Having thoroughly considered all aspects of the topic, the authors say:

*... it is inescapably clear that the amount of meteoritic dust on the lunar surface and in the regolith is not at all inconsistent with the present meteoritic dust influx rate to the lunar surface operating over the multi-billion year time framework proposed by evolutionists, but including a higher influx rate in the early history of the moon (p 36).*

It should be emphasized that there is nothing in the evidence covered by Snelling and Rush that is incompatible with biblical specifications, if the creation account is treated on the basis of the definitions given in Genesis 1:8-10. Creationism has been severely discredited by scientifically inept efforts to defend presumptions that were unjustifiably considered to be mandated by biblical testimony. The publication of “Moon Dust and the Age of the Solar System” is a major contribution to credible scientific creationism.

# GENERAL SCIENCE NOTES

## DID LIFE BEGIN IN AN “RNA WORLD”?

*By L. J. Gibson, Geoscience Research Institute*

### WHAT THIS ARTICLE IS ABOUT

*Recent discoveries of catalytic activity by RNA has stimulated speculation that life may have originated naturalistically through the formation and evolution of RNA molecules. This “RNA World” hypothesis has numerous shortcomings. RNA is difficult to produce chemically. The materials required for its production would not be present on a prebiotic earth. The “RNA World” scenario is not a plausible explanation for the origin of life.*

Explaining the origin of life has remained one of the most bothersome problems for those espousing the view that nature can only be understood within a naturalistic philosophy. For many years the major focus of attention has been on scenarios involving the evolution of proteins. Two historical factors contributed to the emphasis on proteins. One of these was that when scientific investigation of the origin of life was beginning, the role of nucleic acids in heredity had not been established. It was reasonable at that time to suppose that proteins might be responsible for heredity. The other factor was the production of amino acids in simulated prebiotic reactions (Miller 1953). This experimental result seemed to promise the possibility of success in explaining the origin of life, even though nucleic acids were known at the time to be important also in heredity.

For many years there has been a general dissatisfaction with the protein hypothesis of the origin of life. Proteins cannot replicate themselves, making them unsuitable as a starting point for the development of life. However, there seemed to be no naturalistic alternative available until recently. This newer hypothesis has been dubbed the “RNA World” (Gilbert 1986). The basis for this model is the discovery that certain RNA molecules have catalytic properties. Since RNA also serves as a carrier of information, it seemed reasonable to suggest that ancient RNA molecules might have acted as a starting point for the origin of life. The “RNA World” hypothesis for the origin of life seems a significant

improvement over the protein hypothesis, and has been the subject of considerable discussion. The plausibility of that hypothesis is examined in this paper.

### **Importance of RNA**

RNA is present in all living cells, and has a variety of uses that are central to the requirements for life. RNA plays an important role in cellular processes, especially in protein manufacture. Molecules of messenger RNA (mRNA) contain the information needed to specify the proper amino acid sequences of proteins. The mRNA acts as a template for the assembly of protein molecules. Ribosomal-RNA (rRNA) sequences participate in reading the message on the messenger RNA and joining the amino acids together in a chain. Transfer-RNA (tRNA) molecules arrange the amino acids in proper sequence. RNA molecules also have catalytic properties (reviewed by Lamond & Gibson 1990). Messenger RNA molecules often contain non-coding sequences, known as introns. These introns are removed before the message is translated into a protein. The mechanism of removal is self-splicing by the intron, in which RNA acts as a catalyst. Ribosomal RNA can catalyze the formation of peptide bonds between amino acids in the production of a protein (Noller, Hoffarth & Zimniak 1992). Several other examples of RNA catalysis are known. The discovery of RNA catalysis has stimulated the idea that life may have originated with RNA molecules.

Since RNA can act both as a template and as a catalyst, it might be possible that an RNA molecule, acting as a “ribozyme,” could make copies of itself without the need for other kinds of molecules. One strand of a two-stranded RNA sequence could act as the template while the complementary strand could act as an enzyme, catalyzing replication of the RNA sequence (see Cech 1989). Once this step was achieved, variations in sequence would occur which could compete with each other, leading to more complex arrangements. Hypothetically, life might eventually arise. Doudna and Szostak (1989) succeeded in constructing an RNA which would make copies of a template sequence. If an RNA molecule could also make copies of its own sequence, it would be able to replicate both RNA strands, and the cycle could be repeated indefinitely. Another alternative is for two or more different RNA strands to participate in reaction cycles that catalyze each other, forming systems known as hypercycles (Eigen et al. 1981).

## **Reasons for Thinking RNA Preceded DNA**

RNA is thought to have preceded DNA in the origin of life (Lamond & Gibson 1990). One reason for this suggestion is that RNA replication is much simpler than DNA replication, for it involves fewer types of molecules. Another reason is that cells produce DNA nucleotides from RNA nucleotides. A third reason is that RNA primers are required for initiation of DNA replication, whereas RNA polymerases (enzymes that produce copies of RNA sequences) do not require a primer.

### **SOURCE OF BUILDING BLOCKS FOR RNA NUCLEOTIDES**

Nucleic acids are composed of three kinds of building blocks: a sugar, a phosphate, and an organic base. The base may be either a purine or a pyrimidine. These three parts combine to form a nucleotide, which is the basic building block of nucleic acids. In the case of RNA, the sugar is ribose, the purines are adenine and guanine, and the pyrimidines are cytosine and uracil. The production of these building blocks is the first step in the proposed “RNA World.”

### **Production of Ribose**

Ribose, a five-carbon sugar, is an integral component of RNA. Ribose can be produced by the formose reaction, in which polymerization of formaldehyde is catalyzed by a base. This reaction has been proposed as the most likely prebiotic source of ribose. It requires formaldehyde, which is thought to have been present on a prebiotic earth (Kasting 1993).

### **Experimental Support**

It seems plausible that formaldehyde might be produced in reactions among gases in a prebiotic atmosphere that is not strongly reducing (Pinto et al. 1980). Formaldehyde can also be produced by photochemical oxidation of methane. However, at present methane is produced largely as a result of biological activity, and it is unlikely to have been present in significant quantities on a prebiotic earth. Extraterrestrial sources of formaldehyde have also been proposed. Comets and interplanetary dust particles (IDPs) are another possible source of formaldehyde. Comets are said to contain about 25% organic matter, of which 4% may be formaldehyde (Chyba et al. 1990). Production of ribose from formaldehyde has been demonstrated in the laboratory.

## **Problems with Ribose Production**

Although it is conceivable that some formaldehyde could be produced in the atmosphere of a prebiotic world, it is unlikely that significant quantities would be present. There is some doubt that formaldehyde or other organic compounds on comets would survive a collision with Earth. However, even if formaldehyde were present, this does not mean ribose would be produced. Ribose is a very minor product in a complex mixture of compounds produced in the formose reaction, and is rapidly destroyed under the reaction conditions (Shapiro 1988). Furthermore, ribose is considered to be unstable on a geologic time scale, and would probably disappear in a few hundred years (Joyce et al. 1987). A carbon dioxide atmosphere would further inhibit the desired reactions. Carbon dioxide from the atmosphere would dissolve in the ocean, producing acidic conditions that would hydrolyze sugar molecules.

Sugars may be produced in other reactions, but ribose is not one of the products. UV irradiation of formaldehyde produces pentaerythritol, and no ribose (Schwartz & de Graaf 1993). Sugars may also be formed from glyceraldehyde in the presence of iron (III) hydroxide (Weber 1992). However, only hexoses (6-carbon sugars) are formed. There seems to be no plausible prebiotic source for ribose. Additional problems of chirality (mirror image), chemical interference and decomposition of sugar make the production of ribose a major problem for a naturalistic explanation of the origin of life.

## **Production of Purine and Pyrimidine Bases**

It is believed that cyanide present in the primitive atmosphere might be a precursor in the production of purines, pyrimidines and amino acids.

## **Experimental Support**

Maurel states (1992) that purines can be obtained from cyanide in water. The source of cyanide is said to be a major problem in the “RNA World” hypothesis (Kasting 1993). However, hydrogen cyanide is reported to constitute about 7% of the organic matter of comets (Chyba et al. 1990), so perhaps the presence of cyanide cannot be ruled out.

## **Problems with Purine and Pyrimidine Bases**

Kasting (1993) has pointed out that there is no plausible way of forming cyanide in a prebiotic atmosphere. According to De Duve and Miller (1991), the experimental conditions under which purines can be

produced from cyanide are greatly contrived. The presence of a carbon dioxide atmosphere would inhibit the production of purines from cyanide (Chyba et al. 1990). Any purines or pyrimidines present would be hydrolyzed in the ocean made acidic by the presence of carbon dioxide. Pyrimidines are, for all practical purposes, not formed in postulated prebiotic conditions (Maurel 1992).

### **Problems with Phosphate**

Phosphate is required to join the base-sugar pairs (nucleosides) of nucleic acids. Phosphorus is much less abundant than the other elements found in RNA. Yamagata et al. have reported (1991) the presence of polyphosphates (chains of phosphate groups) in volcanic emissions, and has suggested volcanos as a source of the phosphate required for the origin of life. One difficulty with this proposal is that polyphosphates would hydrolyze in water to form insoluble phosphates, which would precipitate to the ocean floor. There seems to be no other possible source of phosphates. An ocean associated with a carbon dioxide atmosphere will be so acidic that phosphate would not be available for chemical reactions.

## **FROM SUGARS, PHOSPHATES AND BASES TO NUCLEOTIDES**

### **Problems of Assembling Nucleotides**

Although the prebiotic production of the building blocks of RNA is highly implausible, there are additional problems involved in combining these units into ribonucleotides. One problem is the production of a mixture of sugars with the ribose. Extra sugars would inhibit RNA synthesis (Horgan 1991). Purines will unite with ribose when heated, but the products include many different sugar-base combinations (nucleosides) and their analogues, and only a small percentage of useful nucleosides (those with beta bonding) (Joyce et al. 1987). Pyrimidines; do not form any useful nucleosides under similar conditions. Under realistic prebiotic conditions, no nucleotides would be formed (Cairns-Smith 1985).

## **FROM NUCLEOTIDES TO RNA**

### **Problems in Combining Nucleotides to Form RNA**

A further problem with the “RNA World” hypothesis is that ribonucleotides may bond in different ways, only one of which is appropriate for RNA (Ferris & Ertem 1992). Ribonucleotides can occur

in D- and L- forms. Only the D forms are useful in living systems, but both forms would be present in any prebiotic mixture. The presence of L-ribonucleotides strongly inhibits the addition of D-ribonucleotides on a template (Joyce et al. 1987). The problem of chirality is so severe that a chirally pure medium seems a necessity for RNA to be produced (Avetisov et al. 1991).

### **FROM RNA TO LIFE**

Even if RNA were produced, there would still be no life. The importance of RNA to the origin of life is based on the conjecture that it could act both as a source of information and as a catalyst to use that information. But RNA must be folded to act as a catalyst, and must be unfolded to act as a source of information (Green & Szostak 1992). In addition, RNA is not a good self-replicator (Horgan 1991). Even if self-replicating RNA should arise, selection would favor greatest ease in replication, and information content would probably be selected against (Wicken 1985). RNA breaks down rapidly in water (Day 1991), especially hot water, or in the presence of divalent cations (Pace 1991). Thus every step in the production of RNA is highly implausible under the proposed prebiotic conditions. Even if RNA were produced, it could not survive nor could it form the basis for a naturalistic origin of life. Some other mechanism must be sought to explain the origin of life.

### **CONCLUSION**

Naturalistic models for the origin of life generally begin with the production of small molecules such as sugars or amino acids, which then combine to form larger molecules such as proteins or nucleic acids. These large molecules must then become organized into cellular structures that are somehow interrelated in complex ways and under non-equilibrium conditions. The “RNA World” hypothesis for the origin of life requires implausible events at each step in the sequence outlined. Small molecules are highly unlikely to have been available in any plausible model of a primordial earth. Even if small molecules were present, they would be highly unlikely to produce the large protein and nucleic-acid molecules useful for life. Even if the large molecules were present, there is no known mechanism whereby they might be organized into functional cellular or subcellular units. The “RNA World” hypothesis



suffers from many of the same problems as the protein hypothesis, and has additional problems of its own. Considering the conditions necessary for the establishment of life, it appears that the most plausible explanation for the origin of life is an intelligent creator.

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# EDITORIAL

## ON ALTERING PAST AND FUTURE

Isaac Asimov's *The End of Eternity* describes a futuristic human society ruled by "The Eternals" — an elite class trained to travel outside Time (i.e., in "Eternity") to make alterations in the Past, Present, and Future. The process would begin with the Observers — individuals who would travel from the Past to the Future and collect data which would be analyzed by a computer. The "All-when Council" would examine the results and determine the Minimum Necessary Change to create the Minimum Desired Response (e.g., both natural and man-made catastrophes would be removed from the past or prevented in the future). A Technician would then travel to the designated time and place to effect the "Reality Changes."

The motivation behind these manipulations was the creation of an idealized human history in which there would be no genocide, famine, or disease. Although the alteration of time lines would unfortunately eliminate some "innocent bystanders" from existence, the changes would supposedly benefit society as a whole. However, according to Asimov's story, humans eventually became extinct because the systematic selection of time lines offering the best options for security and moderation also removed all impetus for advancement and exploration. The deletion of aberrations destroyed the option of experimentation, as well as the potential for triumph over adversity. In such a society, individuals were no longer burdened by personal responsibility for the consequences of their decisions or actions; they could settle comfortably for mediocrity, knowing that the Eternals would erase any mistakes — along with any potential growth that might develop through learning from those mistakes.

Asimov's story was published in 1955, before the advent of our "Space Age"; and his futuristic society seemed totally imaginary. The capacity to travel through time remains an accomplishment only in the realm of science fiction, although the concept is being published in respectable scientific literature. The reader's initial horror over the possibility of his or her time line being eliminated by an impersonal council for the greater good of present-day society or "future history" is quickly replaced by the comforting realization that this potential has not yet been fulfilled.

Upon further reflection, we must ask if a bright future for humanity is guaranteed, so long as time travel cannot be achieved. Is this the only way in which human history can be altered? We are aware that it is not necessary to travel forward in time in order to create the best-possible future; our present choices certainly determine our futures. We are told so continuously through a variety of media, e.g., chain letters threatening

the receiver with bad luck if the chain is broken; advertisements claiming that health, beauty, popularity and happiness are impossible without certain products; and political candidates who warn of the gloomy future that will arise if their opponents are elected.

Despite such widespread emphasis upon our choices and their possible consequences, have we made, and are we making, choices that will jeopardize our future? Apparently the answer is yes. Doomsday forecasting is not a specialty of science-fiction writers, marketing specialists, and politicians. We are also being bombarded by warnings based on intellectual premises. Sociologists, philosophers and educators<sup>1</sup> have expressed concern for an impoverished educational system in the United States, fearing that if the present trends continue, the result will be a nation of illiterates. What has caused this present crisis of ignorance? Is it possible that our "past" is being altered by some culprit which is destroying our chances for a hopeful future?

According to the group which has been collectively termed the "Religious Right" by the public media, intellectual decline is equated with the yielding of Christianity to secularizing influences. Adherents to this viewpoint deplore the decay of moral values, a trend which they believe will lead to the inevitable downfall of civilization.<sup>2</sup> In response, opponents such as philosopher Paul Kurz, editor of *Free Inquiry* and architect of the Humanist Manifesto II, cite the resurgence of dogmatic authoritarian religious (i.e., irrational) groups which thwart the potential for secular humanism's greatness.<sup>3</sup> The tension between the extremes of religious fundamentalism and secular humanism seems unresolvable, with each blaming the other for stifling investigation and limiting the availability of information.

A cursory examination of the arguments apparently favors secular humanism. It seems plausible that religious groups, given their preoccupation with eternal time lines, would be more concerned with censoring (limiting) information that does not support their worldview. For example, legislative attempts during the 1980s to ensure the inclusion of creation-science in public-school science classes (reported in previous issues of *ORIGINS*) were portrayed by their opponents as attempts to impose intolerant (i.e., one narrow viewpoint) religious convictions upon society. Warning that the creation of a "theocracy" would necessarily hinder academic freedom, they proposed that religious ideas, while inappropriate for science classes, should be presented in the context of "history of religions" or the social-studies curriculum. Thus far the U.S. judicial courts have agreed with such reasoning by striking down "creation-science" legislation.

And yet, one wonders if the dominance of secular humanism in the educational process has led to an open forum of ideas which will ensure our best-possible futures. Is it possible that secular humanism also restricts

freethinking? Are some “past time lines” being removed? Investigation reveals that, as social studies have been revised to harmonize with current popular opinion, religion has been determined to be inappropriate also to this curriculum. For example, Catherine Millard<sup>4</sup> has compiled an awesome list of instances in which America’s historical records (especially those which deal with the Founding Fathers and indicate a Christian foundation which does not support the current secular views) have been rewritten, reinterpreted, or removed. In its examination of elementary-school-level textbooks, the Calvin Center for Christian Scholarship<sup>5</sup> describes one series:

*Man is always at the center of the picture the authors paint. What this picture reveals is more than just an absence of God or the Christian religion. It asserts an optimistic faith in the ability of man to both create and shape the world he lives in and to solve his own problems. Like the adherents of naturalistic humanism, the authors seem to believe that man is autonomous.*

Another analyst of socio-religious trends<sup>6</sup> reports that:

*Writers and publishers of textbooks on American history have systematically excluded information about religious motivations, for example in the founding of this country, in the campaign against slavery, in the civil rights struggle, and in the opposition to the Vietnam War. One book on world history omits all mention of the Reformation. A textbook that lists 300 important events in American history includes only 3 related to religion, the last of which was in 1775.*

As can be seen by the above examples, the secularization process has nearly succeeded in erasing the religious “time line” from history. Some would protest that religion has not disappeared and insist that traditional Christian views have merely become transformed into new manifestations. According to this viewpoint, because of humanity’s innate need for the “sacred,” society has created new saviors through the process of “sacralization.”<sup>7</sup> Among these alternative paths to “salvation” are materialism, technology, sociopolitical revolution, and psychology.<sup>8</sup> The British sociologist David Lyon<sup>9</sup> observes. “People, things, events and processes are bestowed with ‘sacred’ status, even as the tide of Christian influence ebbs from Western societies.” Unfortunately, these idols, in which mediocrity and ephemeral values are glorified, are inadequate, dissatisfying substitutes, and the specter of a gloomy future continues.<sup>10</sup> In the words of Allan Bloom<sup>11</sup>:

*Our old atheism had a better grasp of religion than does this new respect for the sacred. Atheists took religion seriously and recognized that it is a real force, costs something and*

*requires difficult choices. These sociologists who talk so facetiously about the sacred are like a man who keeps a toothless old circus lion around the house in order to experience the thrills of the jungle.*

In Asimov's scenario, as noted in the beginning of this editorial, attempts to create the best future by altering the past led to total disaster for humanity. There is a danger of creating a foreboding future; not through the manipulations of time-travelers, but through diluting, withholding, or misrepresenting information in order to appease a secular bias. The worldview created by traditional Christianity, in both personal application and public policy, has shifted from an influential, enriching factor to a sociological curiosity that is no longer necessary in today's world. The spiritual/religious dimension has vanished or been diminished to the role of an atavistic aberration. This situation is deplorable. Our best decisions are based upon complete, accurate information. Without adequate knowledge about our past — including our beginning —, we shall indeed impoverish our future.

Katherine Ching

## ENDNOTES

1. See for example: (a) Bloom A. 1987. *The closing of the American mind*. NY: Simon & Schuster; (b) Hirsch ED (Jr). 1987. *Cultural literacy*. Boston: Houghton Mifflin Co.
2. This view is expressed throughout the writings of the late Francis Schaeffer. While his books are too numerous to be listed here, see especially his: (a) 1976. *How should we then live?* Old Tappan, NJ: Fleming H. Revell Co.; and (b) 1984. *The great evangelical disaster*. Westchester, IL: Crossway Books. Others who express the same themes include: (c) Lindsell H. 1987. *The new paganism*. NY: Harper & Row; (d) Lyon D. 1987. *The steeple's shadow: on the myths and realities of secularization*. Grand Rapids, MI: Wm. B. Eerdmans Publishing Co.; (e) Schaeffer F. [son]. 1981. *Addicted to mediocrity*. Westchester, IL: Cornerstone Books.
3. Kurz P. 1983. *In defense of secular humanism*. Buffalo, NY: Prometheus Books. Isaac Asimov would agree with Kurz; he was a lifelong secular humanist who viewed any belief in the supernatural as a hindrance to the realization of humankind's potential.
4. Millard C. 1991. *The rewriting of America's history*. Camp Hill, PA: Horizon House Publishers.
5. McCarthy R, Oppewal D, Peterson W, Spykman G (coordinator). 1981. *Society, state, & schools*. Grand Rapids, MI: Wm. B. Eerdmans Publishing Co., p 132.
6. Averill LJ. 1989. *Religious right, religious wrong*. NY: The Pilgrim Press, p 169-170.
7. E.g., (a) Ellul J. 1986. *The subversion of Christianity*. Grand Rapids, MI: Wm. B. Eerdmans Publishing Co.; (b) Stark R, Bainbridge WS. 1985. *The future of religion: secularization, revival, and cult formation*. Berkeley and Los Angeles: The University of California Press; (c) Wilson B. 1976. *Contemporary transformations of religion*. Oxford: Clarendon Press.
8. Killinger J. 1973. *The salvation tree*. NY and London: Harper & Row.
9. Lyon, p 96 (Note 2d).
10. See for example: Corwin N. 1983. *Trivializing America; the triumph of mediocrity*. Secaucus, NJ: Lyle Smart.
11. Bloom, p 216 (Note 1a).

# 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: Gibson: Did Life Begin in an “RNA World”? (ORIGINS 20:45-52)**

The harsh reality is that in the annals of science, there are no reports of anyone converting a mixture of complex bio-organic substances (proteins, nucleic acids, lipids and polysaccharides, etc.) to living matter. Under the rules followed by scientists in every other field, this inability to produce living matter from non-living matter should disqualify everyone from claiming any “knowledge” on the subject of biogenesis.

A number of capable scientists have busied themselves for more than 40 years (counting from Dr. S. Miller’s famous experiment) with a parlor game called “chemical evolution.” The rules of this game is to come up with a plausible “primordial earth” scenario which will yield some or all of the biomolecules which are now found in living matter. The distinct impression is gained from reading the chemical evolutionary literature, that as soon as schemes to produce biopolymers are shown to actually work in the laboratory, under conditions postulated to have existed on a hypothetical primordial earth, the problem of the origin of life will be considered solved.

If a collection of biomolecules could, in fact, spring to life spontaneously, then the door would be open for postulating a chemical evolutionary origin of life. Since this is pure fantasy, it makes no difference which biomolecule(s) one supposes to have come into existence in a postulated primitive environment.

Nevertheless, textbooks, monographs, and symposia are filled with the latest in speculations about chemical evolution. Through decades of relentless repetition of this discredited theory, it has assumed the status of a dogma. Nowadays, typical discussions about the origin of life bypass the entire problem of origins, and discussions blithely proceed onto the homologies of the 16S ribosomal RNA sequences or of amino-acid sequences of common proteins among organisms. Apparently no one is interested in the fact that such topics could only have meaning if one already has living primordial organisms, which came into existence through chemical evolution.

So, sadly, articles such as Dr. Gibson’s will have to continue to be written until the scientific community at large will come to its collective senses, and admit that the chemical evolutionary approach to the origin of life was a dismal failure.

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# ARTICLES

## AN INTERVENTIONIST THEORY OF NATURAL SELECTION AND BIOLOGICAL CHANGE WITHIN LIMITS

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### WHAT THIS ARTICLE IS ABOUT

*This paper proposes that mutation and natural selection can produce biological change, but are not sufficient to explain the origins of biodiversity and complexity. Instead, the authors argue that genetic complexity is the result of intelligent design, and was at a maximum when life on Earth first came into being. Mutation tends to produce variants of equivalent complexity at best, and more generally results in reduction of genetic complexity. Some genetic variants may be adaptive in particular environments, but the overall tendency of genetic change is toward genetic loss and degeneration. Natural selection acts to prevent, or at least slow down this process by eliminating individuals that are genetically inferior.*

*The rate of biological change may depend on environmental conditions, and would be especially rapid in the recovery phase of a worldwide catastrophe. Small, isolated populations and changing environmental conditions would combine to promote genetic change and speciation. This effect would be enhanced if genetic systems were designed to respond to environmental stress. Such responses could include an increase in mutation rates, environmentally triggered gene activation or deactivation, and changes in the timing of gene activity. Favorable gene combinations could then be favored by natural selection, in some cases resulting in the rapid appearance of new species.*



Evolution theory has been highly successful in stimulating research and in explaining many biological phenomena. Is there a scientifically viable alternative to the naturalistic understanding of evolutionary genetics? We believe that there is. This article will compare the naturalistic theory of the origin of diversity with a theory of limited genetic change after the major groups of organisms were brought into being by informed intervention. This latter theory recognizes that nature follows predictable laws and that a scientist can count on these laws to be consistent, but does not deny the possibility of intelligent intervention in the process of origins, or of divine involvement in maintaining the constancy of the laws of nature.

This presentation is simply a progress report on our thinking on this subject, and does not claim to answer all of our questions. The theory will no doubt change as we gather more data.

In our theory the *mechanisms* for microevolution and speciation are, in many respects, not significantly different those in from currently accepted evolutionary theories, except for some basic points which will be discussed below. However, it has a different starting point and implies a very different *history* of life. In each section our understanding of the naturalistic theory will be briefly summarized, and an interventionist alternative will then be presented. To be fair to the authors of papers cited here, we wish to emphasize that most of them would not support the basic premise of this paper. We cite them only for specific ideas or data, and we believe that our reinterpretation is not inconsistent with the data cited. Some terms will be defined here: *informed intervention* is a general term referring to any divine involvement in history, including creation of life forms; *microevolution* is genetic change within a species; *speciation* is the development of new species; and *megaevolution* is evolutionary change which produces new families and higher taxonomic categories (Simpson 1953). We will not use the term *macroevolution*, because variation in the definition of that term limits its usefulness in this discussion. A common definition of *macroevolution*, as it is used in the scientific literature, is evolution above the species level (Ridley 1993).

## PHILOSOPHICAL FRAMEWORK

### A. Naturalistic Evolution

It is assumed that every event, past or present, follows natural law. Science will accept only explanations of biological or geological events and processes that are based on the uninterrupted operation of natural laws, which are potentially understandable by science. Hypotheses that

require or imply the existence of any type of divine intervention in earth history at any time are not acceptable.

## **B. Interventionism**

On a day-to-day basis the processes of nature follow natural laws. Living organisms are like “machines” in the sense that we can figure out how they work and what laws govern their structure and function. Thus, scientists who subscribe to this paradigm can work and think much like naturalistic scientists, with one important exception: they do not *a priori* rule out the possibility that an intelligent superior being has, on some occasions, intervened in biological or geological history, particularly in connection with the origin of life forms. Such interventions could have involved the use of laws of nature that are well understood by God, but are beyond current human knowledge. Science cannot test these possible interventions, but science may recognize evidence that points to the existence of these discontinuities or unique events in history. This difference in approach is based on the conviction that if such discontinuities have occurred, it is better to recognize their existence than to ignore them.

## **ORIGIN AND DIRECTION OF EVOLUTIONARY CHANGE**

### **A. Naturalistic Evolution**

According to naturalistic evolution theory, life on Earth began with the evolution of the cell, from which developed the simplest forms of organisms. All structurally complex organisms evolved from these ancestors. All new genes or new information ultimately arose by mutation and recombination. Mutations occur randomly. Most are deleterious and will lower the individual’s fitness or adaptation to its environment (Cain 1989, Maynard Smith 1989). New combinations of the genetic material are formed by reshuffling of combinations of characters during sexual reproduction. Natural selection eliminates the deleterious mutations and preserves the available combinations that are best adapted, in the organism’s environment, for maximizing successful reproductive effort (Endler 1986).

Within each taxon (taxonomic group, such as a genus or family), the first forms did not have the advanced characteristics of that group, but had primarily the characteristics of the group that was its immediate ancestor. Within each taxon, evolution progressed from the ancestral state toward forms with more derived characteristics (new characters that were not present in their ancestors) in their external appearance, as well as in their anatomy, physiology, behavior, and ecological adaptations. At

lower taxonomic levels (within a species, genus, or family) these derived characteristics would not necessarily be more complex, but at some level in the evolution process structures and physiological systems were evolving that did not exist before. The overall picture is of the evolution of the complex whole of modern life from structurally simple initial life forms.

## **B. Interventionism**

According to the interventionist theory, at the creation of life on Earth, representatives of all major extant and extinct groups of plants and animals were present. Living things were as complex at the beginning as they have ever been. The earliest forms were at least as complex, although not necessarily as specialized, as any modern-day representatives of their group in their external appearance, anatomy, physiology, behavior, and ecological adaptations. In these early populations the amount of genetic information and the potential for genetic diversity per species may have been at the highest level that it has ever reached. The high point of the complexity of life on earth was at the very beginning.

Complexity in plants and animals was the result of intelligent design. Organisms were designed with a genetic system which possessed the capacity for genetic variability that would permit the organism to adapt physiologically to changing conditions and to produce new species and varieties that would be new variations on existing themes. At first this process did not involve the primarily destructive element of random mutations, but utilized the potential for variability built into the genetic system. The first populations of the original species were not all alike — there was considerable variation in their characteristics — and they probably had a genetic system capable of generating additional diversity when needed, by producing new alleles or by switching on stored, unexpressed genes.

As time went on, environmental changes occurred that increased the mutation rate. Radiation and other mechanisms began to produce random genetic damage (i.e., mutations), and/or there was a decrease in the efficiency of the gene replication and repair mechanism. Since mutations are mostly deleterious, the damage must be controlled to prevent life from going extinct. Natural selection has been the agent which has eliminated the less-fit individuals, and has assured that, on average, those which reproduce are the healthiest and best adapted to the environment in which they live.

Within each group of organisms, the origin of new morphological variation has involved two basic components. First is adaptation to changing

conditions by production of new alleles for existing genes and selection for those alleles best suited to the environment, by the generally accepted processes of microevolution. An example of this type of adaptation to the environment is the development of dark pelage by a rodent living on dark soil (Dodson & Dodson 1985, p 194). Another example is the behavioral adaptation of marmots to differences in climate (Barash 1974). Marmots have adapted to alpine areas with short summers and to milder, low-elevation climates by changes in aggressiveness, coloniality versus territory defense, and rate of maturation. They reach sexual maturity in two years in alpine areas, and in one summer in lowland areas. This adaptation process does not necessarily involve either increase or decrease in complexity, nor the evolution of new genes or structures. Perhaps it could involve the turning on and off of genes by environmental signals. Thus new characteristics might be caused by formerly inactive genes.

A second component of morphological variation is the tendency toward loss of genetic information in organisms since their origin. Examples are loss of flight by some birds and insects, and loss of sight by cave organisms. We argue that organisms today are, on the whole, less complex and less adaptable, and the interactions between organisms in ecosystems are less finely tuned, than at the beginning of life on earth. In most cases natural selection tends to slow down the loss of information by eliminating defective individuals, unless the environment allows or favors the genetic loss.

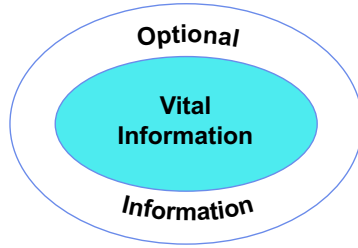
## **LOSS OF GENETIC INFORMATION**

### **A. Naturalistic Evolution**

Since most mutations are harmful, there is the potential for effective loss of genetic information, unless natural selection is able to eliminate the damaging mutations. An animal species has a certain amount of genetic material, some of which is absolutely vital for survival of the species. Another portion of the genetic information is optional, and includes behavioral and physical traits that the species can lose and still be viable (Carson 1975) (Figure 1). Which features fall in this category will depend on the environment.

For most birds flight is vital, and loss of flight would probably doom the bird to extinction. However, on an island with no predators, losing the ability of flight might not be a problem and might even be an advantage in a tropical storm that can blow flying birds out to sea. There are a number of species of flightless birds, and most of these are on islands (Diamond

**FIGURE 1.** A representation of the total genome of a species, and the core of vital genetic information that is necessary for life.



1981). Flight is optional in that situation, and this illustrates how a certain amount of genetic loss is possible. Other examples of genetic loss are blind cave salamanders and parasites that lack a digestive system.

Where have parasites such as tapeworms come from? It appears that their origin involves the loss of much genetic information as they degenerated from a free-living state. Tapeworms do not have some organs that similar, non-parasitic worms have. They don't have a digestive tract, but are essentially a highly developed reproductive system that lives in the intestine of their host. All the nourishment they need is absorbed through their skin. In this situation the tapeworm doesn't need a digestive tract; all it needs is a way to reproduce itself and maintain its location. If ancestral tapeworms with normal digestive tracts mutated, the loss of those digestive tracts would not have been disadvantageous, because of the nutrients available from the host. In this situation an organism can lose much more than is possible in other environments, and still be viable. These degenerate parasites exemplify change by loss of information.

## **B. Interventionism**

Interventionist theory accepts the explanations given above for flightless birds, cave salamanders, and parasites. What would be the purpose of creating tapeworms and mosquitoes? It seems much more likely that these and other parasites have reached their present form through degeneration — loss of genetic information leading to dependence on parasitism. Cave salamanders and flightless birds have lost certain traits through mutation and natural selection, as described above, in the process of adapting to new environmental situations.

The interventionist theory presented here also proposes that loss of genetic information has not only been involved in the extreme cases described above, but has been a subtle and pervasive part of the genetic change in animals and plants since their original creation. The following example of possible loss of information is probably more typical than the type of loss

experienced by some parasites or by blind salamanders. William Dilger studied the behavior of African lovebirds of the genus *Agapornis*, which are in the parrot family (Dilger 1960, 1962). He arranged the species of lovebirds in an evolutionary sequence. At one end of the sequence is a species that does not have the specialized features of some other lovebirds; it is very plain colored, has a simple courtship ritual, and makes a crude nest. The species at the other end of the *Agapornis* family tree consists of beautiful, colorful birds with more complex courtship, and which build elaborate covered nests. Several species are intermediate between them.

The usual interpretation of such a sequence is that the plain lovebird, with fewer characteristics unique to lovebirds, was near the beginning of the family tree, and the species with more specialized lovebird characteristics was the most highly evolved. But how can we be so sure that the changes didn't go the other direction? How would we decide? Usually the decision would be based on the initial assumption that these lovebirds have evolved from other, related types of birds. If that is done, it is reasonable to assume that the species with the least specialized lovebird characters is closest to the base of the lovebird evolutionary tree.

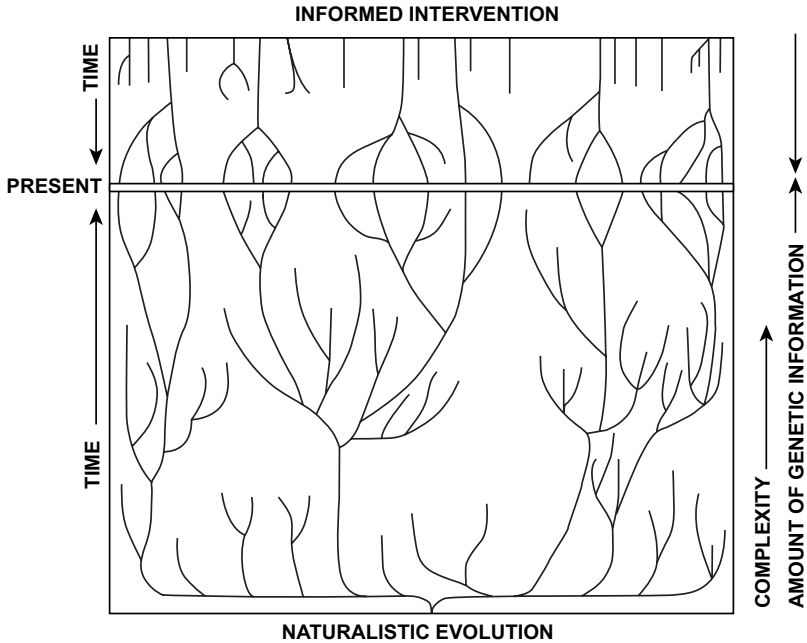
If we do not assume that all creatures have evolved progressively (in this instance, from another kind of bird), we can also consider the option that their evolution went the other way, starting with a lovebird with the most uniquely lovebird behavior and bright colors. Since the origin of those lovebirds, some species have lost varying amounts of genetic information, depending on the selection pressures to which each has been exposed. What has been lost are some of the specialized features — the optional information that is not required to be a viable lovebird.

The result of the above-postulated process of genetic loss is that while the number of species of lovebirds has increased, there has still been a tendency toward loss of information. Many species are highly specialized and live only in a narrowly defined ecological niche. That is part of the reason why we have such a problem with extinction of species today. Man changes the environment, and many species cannot adapt to these changes because they have lost the ability to adapt. In contrast, some species are quite variable, or polymorphic, and adaptable. The coyote today is an adaptable species and has increased its numbers and its range, while less-adaptable species are becoming extinct.

Naturalistic evolution theory recognizes that groups of organisms may become divided into many species, each adapted to a specific niche. This specialization may be accompanied by loss of features or abilities that are

needed by more generalist species. Hinegardner (1976) indicates that species with lower amounts of DNA tend to be more specialized. Our theory proposes a similar concept, except that the process started with a rich array of created life forms. Since the original creation of organisms, populations that were originally adaptable, with a high level of genetic information, have often become highly specialized, possibly with less genetic information per species. During this process many taxa have also divided into numerous species, with each species being specialized. Division of the original groups into the many specialized species of today is not just the latest minor episode in the history of life, but a major part of the change that has occurred since life began on this earth. Figure 2 illustrates the basic differences between the two theories.

**FIGURE 2.** Comparison of the implications of the two theories of origins. The lower phylogenetic tree shows increased complexity through time. The upper tree (for the same organisms) shows independent origins of major groups, followed by speciation and some decrease of complexity through time.



## NATURAL SELECTION

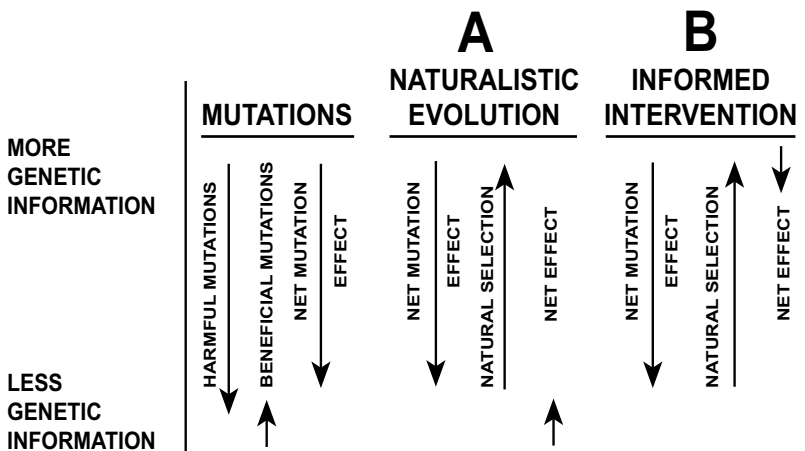
### A. Naturalistic Evolution

The naturalistic theory of evolutionary change begins with the genetic material provided by random mutation and recombination. Natural selection is the key process that rises above the randomness of mutation and selects the appropriate features to improve the adaptations of organisms. Most mutations are harmful, but natural selection is effective in eliminating most destructive mutations and preserving the beneficial ones, and consequently the net effect is upwards, towards improved adaptation to the environment, and ultimately the production of new genes, new adaptations, and even new organ systems (Figure 3A).

### B. Interventionism

Both naturalistic evolution and informed intervention recognize natural selection as an important factor in the microevolution process, but the specific role of natural selection differs in the two theories. This interventionist theory recognizes the same forces, but suggests that the balance of forces is different. Edward Blyth anticipated Charles Darwin's theory of natural selection, but Blyth was not an evolutionist. He viewed natural selection as a conserving force, maintaining the species by eliminating the weak individuals (Eiseley 1979). Lester and Bohlin (1989)

**FIGURE 3. The balance of natural forces according to (A) naturalistic theory and (B) interventionist theory.**





have suggested that Blyth was more correct than Darwin and that evolutionary change occurs only within limits. Informed interventionism suggests that mutation and natural selection are not able to produce an increase in complexity by generating new genes and organs. They are only able to change animals within the constraints of their original genetic potential, and to slow down the slide toward oblivion which would occur if the accumulation of harmful mutations were not held in check. Natural selection is nearly able to offset most of the deleterious effects of mutation, but the net evolutionary change is slightly downward (Figure 3B). Natural selection acts as a brake, to eliminate many of those individuals that have been weakened by mutations, and thus to slow down the destructive forces that can come from mutation.

This theory of natural selection is actually not a new or radical idea, and does not seem to go against the data that are available, even though Ridley (1993, p 508) claims that “no one seriously doubts that the micro-evolutionary processes...[described earlier in his book] are fundamentally responsible for all evolution in the history of life.” He does not support that claim with convincing *genetic* evidence that the proposed mechanism can accomplish the task, and some other non-interventionist scientists question whether natural selection can actually do some of the things that the neo-Darwinian synthesis maintains that it does (Arthur 1984, ch 4; Bakker 1985; Ho & Saunders 1979; John & Miklos 1988, p 336; Løvtrup 1987, ch 12). They are not suggesting that animals were created, but that the traditional process of point mutation and natural selection is not the process that generates significant evolutionary change. Interventionist theory recognizes that natural selection is a significant force, but suggests that it is not able to generate significant new structures, and that there is no other evolutionary mechanism that can do so.

## **EVOLUTION RATE**

### **A. Naturalistic Evolution**

In naturalistic theory all new variability is ultimately the result of random mutations. Reshuffling of the genetic material provides many new combinations of traits for natural selection to act on, but the raw material is only provided by mutation. Mutations occur at random in relation to the needs of the organism, and most mutations are deleterious. Therefore evolutionary rates are usually very low; significant morphological change and megaevolution require a great amount of time.

## B. Interventionism

Even though interventionists are often thought of as anti-evolutionists, the fact is that young-earth interventionists have to believe in a far more effective and rapid process of morphological change than non-interventionists. They have a shorter time period for the evolution of a large number of species and genera of organisms. Is that realistic? Actually there are important features of interventionist theory that would be favorable to rapid rates of change. First of all, the major taxa were in existence from the beginning. All that is needed is a process of diversification within each major taxon. The interventionist theory does not depend on new structural and biochemical traits evolving through mutation and natural selection. Change comes rather from a sorting out of genetic potential that was already present and from some loss of information and from differential gene expression. Net evolutionary change has been downward, or toward loss of information. Thus the evolution process has not been dependent on uncommon beneficial mutations, but utilizes the high level of genetic information that was a part of the original design. When the influence of the environment permits additional change by loss of information, the numerous deleterious mutations whose effects are otherwise held in check by natural selection speed the process of biological change. Thus expected rates of genetic change would be much higher than predicted by the naturalistic theory.

According to the theory presented here, much of our current taxonomic diversity has been the result of limited evolutionary change after a worldwide catastrophe. The original groups of plants and animals have diversified into multitudes of species, as they adapted to fill specific niches in the changed conditions after the catastrophe. If we consider the conditions that would likely exist after such a worldwide catastrophe and compare them with factors that are known to favor rapid genetic change, we find that conditions at that time would be ideally favorable for rapid change.

1) An abundance of potential, unoccupied niches to which organisms could adapt. Animals that have successfully colonized islands have often developed a large number of species. Examples of this are the fruit flies and honeycreepers of Hawaii, and the Darwin's Finches of the Galapagos Islands. Apparently this speciation is facilitated by open niches and the resulting lack of competition (Ford 1964, ch 2).

2) Before the development of mature, balanced ecosystems, population dynamics would be unstable. This would result in flush/crash population

dynamics: populations of animals expand, with all genotypes surviving, until they use up their food supply or until expanding predator populations catch up with them. The resulting population crashes produce the population bottlenecks (a time with few individuals in the population) favorable to speciation. Those individuals best adapted to particular niches will have the best chance of surviving the crash. Several, or many, species could be created simultaneously by a series of such cycles (Carson 1975; Mettler et al. 1988, p 295).

3) Rapid geologic and environmental changes would favor the separation of organisms into isolated populations, which also facilitates speciation (Mayr 1970). This might have been particularly important for aquatic organisms, plants, and terrestrial invertebrates, which would likely have survived the global catastrophe in many scattered, isolated pockets. As the animals moved out over an empty world after the catastrophe, there would be almost limitless opportunities to occupy available new niches and speciate. In this situation, ecosystems initially would have been simple, and relatively unstable. Until mature ecosystems developed, many population fluctuations would likely occur. These, along with rapid geologic changes in the recovery period, would divide animal populations into smaller populations. The result would be a potential for very rapid rates of biological change after the global catastrophe (perhaps the most favorable situation for speciation we could imagine). The rate of change would slow down as environments and population dynamics stabilized, available niches were filled with increasingly specialized species, and ecosystems became more complex and balanced.

The overall implication of this theory is that evolution within the potential of the genetic system can be very rapid when conditions are favorable. Most of the modern (recent, or Holocene) species of animals evolved during the first few hundreds or thousands of years after the global catastrophe. Although it is commonly assumed that speciation takes hundreds of thousands or millions of years, even in modern times introductions of monkeys, birds, copepods, and moths to new geographic areas has produced change equivalent to new subspecies or species in time spans of 30 to 1,000 years (Ashton, Flinn & Griffiths 1979 [green monkeys]; Baker 1987 [mynas]; Johnson 1953 [copepod]; Johnston & Selander 1964 [house sparrows]; Zimmerman 1960 [moths]).

There is evidence that population bottlenecks usually reduce genetic variability (although usually only rare alleles are lost). This is a possible challenge for our theory of post-catastrophe evolution, because of the

expected loss of genetic variability in those species with small numbers of individuals surviving the catastrophe. This leads us to suggest that there must be mechanisms to rapidly increase genetic variability after a population bottleneck. Observations of much higher genetic variability than expected after experimental or natural bottlenecks provide some evidence for the existence of such mechanisms (Carson & Wisotzkey 1989; Dessauer, Gee & Rogers 1992; Mettler, Gregg & Schaffer 1988, p 296; Terzian & Biemont 1988). There is evidence that environmental or genetic stress produces genetic instability, with increased rate of recombination and increased mutation rates resulting from higher activity of movable elements (jumping genes) (Fontdevila 1992; Parsons 1987, 1988). Movable elements seem to produce most spontaneous mutations in *Drosophila* (fruit flies) (Langridge 1987) and in other eukaryotes (Reanna 1985). They have been implicated also in transferring genetic information from one type of organism to another, even from one kingdom to another (Amabile-Cuevas & Chicurel 1993). Some have even suggested that environmental stress can “induce” mutations which will be beneficial to the organism, although that is highly controversial (Cairns, Overbaugh & Miller 1988; Lenski & Mittler 1993; Moffat 1989; Revkin 1989).

An extension of this hypothesis suggests that the original genetic systems contained pre-programmed options susceptible to environmental induction. Perhaps organisms were originally designed with an effective mechanism for increasing genetic variability, to meet changing conditions. These mechanisms may have suffered, after that time, from mutational damage, and no longer are as effective or as reliably beneficial as they originally were. Movable elements may originally have made only regulated movements between specific sites on the chromosomes. Some such movements are still quite specific, but mutational changes in the system may have reduced their specificity.

## **REGULATORY GENES AND HETEROCHRONY IN EVOLUTION**

### **A. Naturalistic Evolution**

Advances have been made by conventional evolutionary theory in understanding processes that can generate significant change with a minimum of genetic innovation. These processes center around changes in regulatory genes and alteration of growth processes during embryological development (see Alberch 1985; Arthur 1984; Avers 1989; Futuyma 1986; Gould 1977; McKinney & McNamara 1991; Valentine 1992; Valentine & Campbell 1975; Valentine & Erwin 1987).

The genetic material contains both structural genes that produce specific proteins and regulatory genes that control the activation of the structural genes and determine when, in what cells, and for how long, each structural gene produces its unique protein. It has been recognized that to produce significant evolutionary changes merely by a succession of mutations in structural genes would be a painfully slow and unlikely process. A different process has been suggested that relies more on changes in regulatory genes. The first step in the process would be the evolution of a great variety of structural genes, through the action of gene duplication, mutation and natural selection. When living systems contained a sufficiently diverse array of structural genes, novel body plans would result from changes in regulatory gene systems, altering the patterns of activation of the structural genes. New body plans would be primarily just new combinations of features *that were already present*, and consequently the establishment of these new body plans (new phyla) could proceed rapidly, in relation to geologic time (but still over thousands to millions of years).

It is claimed that regulatory changes can be particularly effective if they alter the pattern of embryological development. A minimal amount of genetic change in the timing of developmental events (heterochrony) might result in significant morphological evolution. Accelerating or retarding the time of reproductive maturity (adulthood) relative to physical growth can cause quite different effects depending on the direction of the change. For example, speeding up maturation relative to physical growth can result in paedomorphosis, which is the retention of juvenile characteristics in the adult. If this results in adults with small body size, it is called progenesis; and if the adult is at least as large as its ancestral form but retains juvenile features into the adult stage, it is neoteny. Some salamanders have gills as larvae but not in the adult form. Other, neotenic species retain the gills as adults (Figure 4).

Timing of embryonic events apparently controls the stripe pattern in some zebras. The stripes on the lower back of the zebra *Equus burchelli* are widely and irregularly spaced, as the result of differential growth rates of the embryo after the stripe pattern is established. The stripe pattern in *Equus grevyi* is not established until that differential growth is completed, and consequently the stripes in the adult of this species are more equally spaced (Figure 5).

Allometry, or differential growth, has been proposed to explain the differences, for example, between several species of fossil titanotheres (Figure 6) (Futuyma 1986, p 368). The change from one species to another

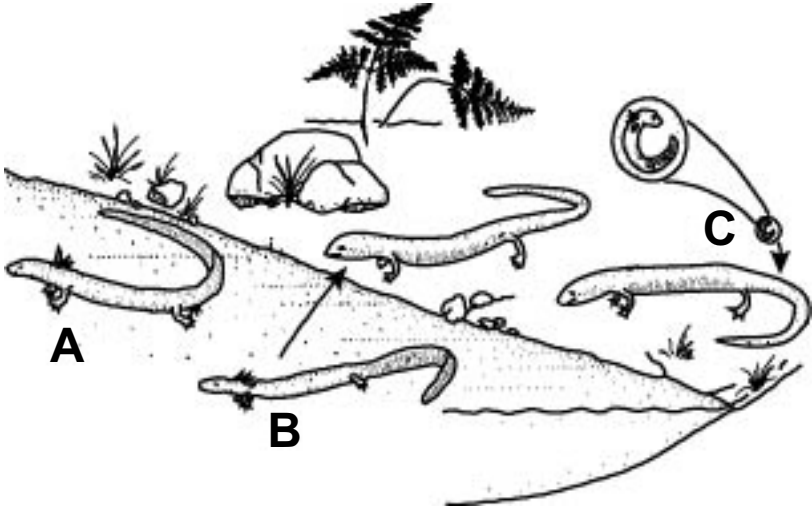
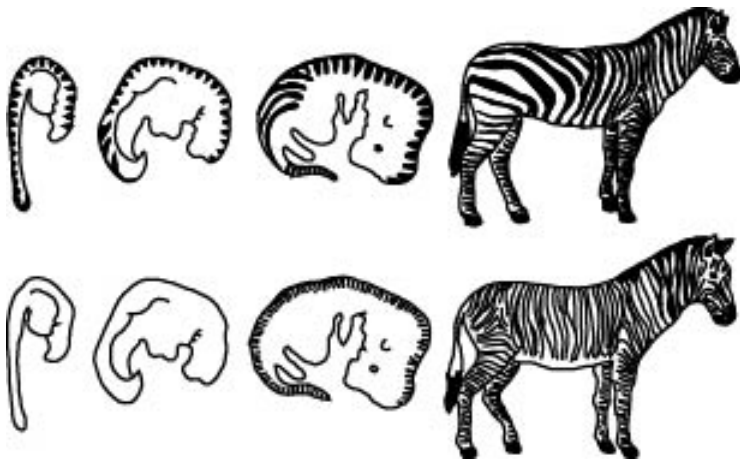
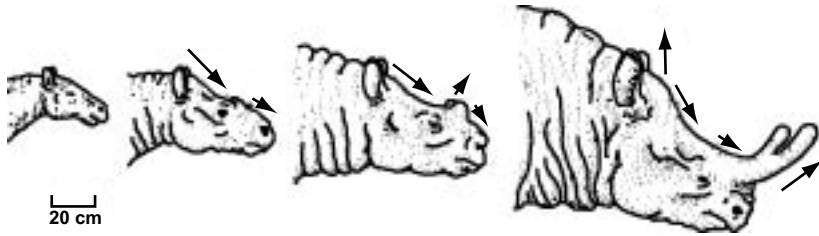


FIGURE 4. Three different salamander life histories: (A) aquatic adult salamander with larva's gills and tail fin; (B) aquatic larva with gills and tail fin that becomes a terrestrial adult with no gills or tail fin; (C) fully terrestrial salamander with larva that loses its gills and fin when it hatches from the egg. Illustration drawn by Carole B.

FIGURE 5. Embryonic development and stripe patterns of the zebras *Equus burchelli* (top) and *Equus grevyi* (bottom). Illustration drawn by Carole B. (after Alberch 1985).





**FIGURE 6.** Four species of fossil titanotheres showing allometric growth. Arrows show relative growth in comparison with the species to its left. Illustration drawn by Carole B. (after Futuyma 1986).

is simply increased overall size, and proportionally faster growth of the horn and certain other facial features. These examples illustrate the theory of how small genetic changes over long periods of time can produce significant morphological evolution.

### **B. Interventionism**

According to interventionist theory, the above-described processes of regulatory gene mutations and heterochrony would not produce new body plans or other major changes, but at lower taxonomic levels (for example within a family) they would perhaps help to explain how a significant amount of change could occur rapidly. The original array of structural and regulatory genes for each body plan did not arise by mutation and natural selection, but were invented by intelligent design. The mechanisms described above are part of the process for introducing variations within each body plan, for the purpose of permitting species to adapt to changes in their environment. The gene switching model of Oster and Alberch (1982) also suggests how morphological change could occur by switching from one embryological “program” to another, with each program leading to a different morphology. Other mechanisms, which are beyond the scope of this paper, have been proposed.

## **SOCIOBIOLOGY**

A naturalistic theory of evolution must be able to explain the origin of all animal behavior, and sociobiology claims to provide the mechanism to accomplish this. A previous article (Brand & Carter 1992) discussed sociobiology, its success in explaining many aspects of animal behavior, and its implications for human biology. Alternative explanations for the data in this field are discussed below.



## **A. Naturalistic Evolution**

Sociobiology theory claims that the behavior of animals is biologically determined (i.e., genetically controlled) and that its evolution has been governed by the incessant evolutionary competition between genes. Complex behaviors have evolved from simple behaviors, generally from simple maintenance routines such as preening, eating, and defense. These behaviors became elaborated into more complex behaviors with new functions. Complex social behavior, including seemingly “altruistic” behavior, has evolved only as this behavior resulted in increased inclusive fitness through kin selection. In other words, an animal will perform only those behaviors that will maximize the passing on of its genes, either through its own survival and reproduction or by assisting the survival and reproduction of its relatives who share many of the same genes that it has. Thus there is no truly altruistic behavior; behavior that appears altruistic has evolved only because it serves the interests of the “selfish genes” and has increased the potential of these genes to be passed on to more offspring.

## **B. Interventionism**

According to interventionist theory the original animals had the greatest level of complexity in their behavior, and the interspecific and intraspecific interactions between organisms were the most finely tuned and harmonious at the beginning of life on Earth. Potential conflicts between animals over the division of territory and other resources were originally settled by non-damaging conventional displays like those still common in a number of animals. Examples include the male rattlesnake wrestling matches and the lizard tail lashing or head butting “battles.” True altruistic behavior may have been much more common. Perhaps it was originally common for subadult animals to assist their parents in raising the next brood or litter. Population control mechanisms were also much more finely tuned than at present. Behavioral mechanisms for maintaining a stable ecological balance were built into the animals’ genetic makeup; part of an ecological system that originated through intelligent design rather than chance.

The instinctive behavioral mechanisms which prevented damaging conflict were not originally subject to random mutational changes. Because of adequate protection from mutational damage, individuals with these behavioral mechanisms would not be subject to unfavorable competition from individuals who would benefit from behavioral “cheating.” With the introduction of random mutations these behavioral mechanisms began to break down.



Natural selection, and especially kin selection, has acted to slow this breakdown. The altruistic behaviors which have survived the negative effects of mutation are primarily those that have been preserved by kin selection and that increase the inclusive fitness of the organism. When mutations began to cause the loss of some of the original created behavior patterns, natural selection would inevitably come into play and determine whether the original type or the mutated type would become most common. If mutations in a female bird removed the original pattern of helping her parents raise their young, and she built her own nest, she would likely produce more young in her lifetime than other young who began reproducing later (this is the same result that would be expected by naturalistic theory). As a consequence the “non-helper genome” would become more common and eventually replace the “helpers.” On the other hand, in some situations the genes for “altruistic” behavior are favored by kin selection, and consequently will continue to be common in the population. The Florida Scrub Jay lives in a situation in which the young are not likely to successfully reproduce the first year, and consequently their inclusive fitness will be increased if they help their parents raise young which share many genes that they also have. In this way more copies of their genes will exist in the population than if they didn’t help their parents that first year, and thus kin selection favors retention of the “altruistic” behavior in this environment.

Mutation and natural selection have no ability to look at the “big picture” and see what is best for the overall ecological balance. Natural selection is strictly shortsighted — it favors any change that increases successful reproduction. The ultimate result of the rule of natural selection in nature is the competitive, vicious side of nature.

## CONCLUSION

This interventionist theory has a number of implications for the genetic system, along with suggestions for future research. An obvious implication is that with adequate genetic variability and changing environments, morphological change and speciation can occur rapidly, even orders of magnitude faster than is commonly believed. Animal populations that are well adapted to their environment would not be expected to change, but rapid evolution within limits is seen as the normal expectation under some environmental conditions, especially when rapid environmental changes are occurring.

We propose that evolutionary change has occurred only within definite limits, but the limits are not at the species level. Because of the subjectivity

involved in defining higher categories in different animal groups, it will not be possible to define the limits of the original groups of animals and plants in terms of a specific taxonomic level such as family or genus, but preliminary analysis suggests to us that almost all modern species, probably most modern genera and perhaps some families, have resulted from modifications of the originally created species.

These changes involved mutations and natural selection, loss of some information, and adaptation to changing environments. Changes in regulatory genes have probably been an important factor making rapid change possible, since small genetic changes produce relatively large phenotypic effects. Could even the series of titanotheres and horses have resulted from these processes?

Naturalistic theory proposes that the existing structural genes accumulated through the action of mutation, recombination, and natural selection. The process is believed to have been facilitated by duplication of genes, producing excess genetic material that could then be modified by mutations, eventually becoming new genes coding for new proteins. Much of the genetic material in organisms consists of "silent DNA" with no known function. Part of this DNA contains pseudogenes, which appear to be copies of known genes, but with mistakes in them. Pseudogenes and other silent DNA are usually interpreted as duplicated genes that can evolve into new genes.

It is being recognized that more of the "junk DNA" is functional than had previously been thought (Nowak 1994; Reynaud et al. 1989). We think that this trend will continue, and it will be found that much more DNA is involved in regulation than is currently recognized. When we consider all of the control mechanisms needed to regulate when and where each protein will be made and in what quantity; the development of each different organ and its growth and integration with other organs; the functioning of the tremendously complex biochemical systems in each cell, as well as controlling how long your nose will be, it becomes evident that a vast complex of regulatory genes is needed. There are certainly many more regulatory genes than structural genes, and we predict that in most organisms, the amount of DNA needed for structural and regulatory genes is much greater than presently recognized.

However, we cannot rule out the likelihood that in some cases mutations may have produced extra copies of genes. For example, it is puzzling why the amount of DNA per organism varies by two orders of magnitude in

fish and in insects, and by three orders of magnitude in algae and in angiosperms (John & Miklos 1988, p 150).

Is it actually possible for complexes of structural and regulatory genes to originate through mutation, recombination, and natural selection? This requires that the duplicated DNA gradually accumulate beneficial changes that can be selected for, and that this process can produce a new gene with a new function. Is it possible for this to occur with no intelligent input, producing not only a new structural gene but also the complex of regulatory genes that recognize and control it? We predict that the answer is no.

It has been proposed that the evolution of resistance to insecticides, and new enzymes appearing in laboratory cultures of bacteria, etc., are examples of this process. As our understanding of the details of the genetic material improves, along with more effective techniques for analyzing it, it should become possible to test the theory that mutation and natural selection can produce new genes. Are those actually new enzymes that appear in bacteria cultures, or just the activation of genetic potential that was already there but not in use (or at a low level) before the environment was changed (Opadia-Kadima 1987)?

Research should focus on determining the exact genetic information in organisms used in the research described above so that it will be known whether new genes actually appear by the hypothesized process. Perhaps it would also be possible to induce sufficiently accelerated mutation rates to attempt to duplicate the gene evolution process in the laboratory. Efforts are also being made to develop computer simulations of genetic systems (Maynard Smith 1992). As our understanding of genetic mechanisms improves, perhaps the sophistication of such models could become adequate to realistically test theories of gene evolution.

It seems most likely to us that any process of genetic change which depends on random mutations as the ultimate source of new information will tend to produce disorder, and will never construct any new gene complexes. Until that prediction can be falsified, the theory of naturalistic megaevolution of higher categories from a common ancestor stands on a weak foundation.

The evidence suggests to us that quite a bit of speciation and morphological change has occurred, and the reinterpretation of evolutionary genetics presented here is proposed as a step toward understanding the process of change that brought life from the original created state to its present adaptation to modern conditions. We propose that these genetic

mechanisms are adequate only to diversify and adapt life from the original created taxa, and cannot produce an increase in the complexity of life. The evidence for a genetic mechanism adequate to produce increased complexity and new body plans is far from compelling.

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