EDITORIAL

THE DISREGARD FOR DISCARDS

I was listening to the chairman of the House Education Committee of the State of Oregon discuss the merits of the creation concept. He felt that creation was not valid. It had had its chance, it had been tested by science and had been discarded, it was therefore no longer worthy of consideration. This line of reasoning is common. A recent documentary film issued by the Scientific Research Society of North America iterates the same theme; namely, that the idea of creation had been rejected by scientists long ago. I heard somewhat the same concept expressed at a meeting sponsored by the Biological Sciences Curriculum Study. Here the speaker declared that biology textbooks should boldly assert the fact of evolution because, as he stated, "after 100 years [since Darwin] it's about time."

These arguments center on the concept that once an idea is discarded, it is no longer valid. This is not necessarily the case. The history of science reveals that ideas can be rejected for erroneous reasons; later, when the error is discovered, the discarded ideas are again considered valid.

Up to the 16th century there was a general belief in the spontaneous generation of life. It was commonly accepted that simpler organisms such as flies, frogs, and moths spring spontaneously from sources such as mud, decaying carcasses, water, and even fog. In fact Van Helmont (1577-1644) gained some notoriety by providing a formula for manufacturing mice. It consisted of putting grain, cheese, and old rags in a container and leaving it undisturbed in a quiet dark place like an attic. After a while mice would appear. While the results of Van Helmont's experiments can still be confirmed today, we do not agree with his inference that mice can arise spontaneously.

The battles over spontaneous generation that ensued a little later, especially the ones over the origin of microorganisms, were prolonged and tedious. They finally ended with the carefully worked out experiments of the French scientist Louis Pasteur (1822-1895). He helped confirm the principle of biogenesis which states that only life begets life. Spontaneous generation had passed from an accepted to a discarded idea — but not for long. The idea that life can arise by itself is again given serious consideration albeit in a different format than Van Helmont's experiments with mice. The contemporary biological literature that discusses how life could have arisen by itself is extensive. Even high-school biology textbooks go into detail describing the primitive conditions under which life could have

originated spontaneously, and a number of noted scientists have devoted their careers to supporting this concept.

The question of hibernation in birds is another example of the reacceptance of a discarded idea. In the ancient world and also more recently, it was generally believed that birds hibernate. Aristotle himself is thought to have believed that storks hibernated in trees. It was a reasonable way of explaining the disappearance of birds in winter, for, as with some of their mammalian counterparts, it was thought that they were "sleeping" during the cold winter months. Many centuries later as the science of ornithology developed, it was discovered that birds disappear in winter not because of hibernation but because they migrate to a more salubrious environment. It was learned that some birds (e.g., the arctic tern) travel as far as 11,000 miles. Thus migration became the accepted dogma. All seemed well until the naturalist Edmund C. Jaeger discovered a poorwill unmistakably hibernating in a cave in Southern California! We are back again, at least in part, to the belief that birds hibernate.

Because scientists sometimes readopt once-rejected ideas, it does not seem valid to argue that creation should no longer be considered because it is a discard. As new information comes forth, old ideas that better fit the new data may be revived.

An asset of scientific methodology is its openness to ideas and its consequent willingness for revision. However, this openness is negated if old ideas are not reconsidered as new pertinent data come forth. Creation may be a discarded idea to some scientists, but it can also be an idea to be tested and retested by science as new information becomes available.

It is noteworthy that some scientists have never discarded creation. One main reason is that no one has been able to come up with a competing idea that explains all the evidence for intelligent design in our natural world. To a number of scientists it is too much to expect that all of life with its impressive complexities at several levels of organization came about as a result of only natural causes. Until evolutionists can provide better answers to this and other basic questions of origins, it is especially important not to label the creation concept as unworthy of reconsideration because it has been discarded. This is not the way science works.

Ariel A. Roth

REACTIONS

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Letters

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THE EDITORS

ARTICLES

AMINO ACID DATING

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ABSTRACT

Investigation of amino acids in fossils over the past thirty years has revealed that residual amino acids may exist in fossils from throughout the Phanerozoic portion of the geologic column, that the amino acid pattern in a given fossil changes with age due to differences in stability among the twenty amino acids of which proteins are constructed, and that the ratio of right-handed to left-handed forms (D/L ratio) of amino acids increases with age from zero in the proteins of living organisms to the ratios which are characteristic of amino acids produced synthetically (the racemic ratios).

The possibilities for using these characteristics as a means for determining fossil age are frustrated by variations of the amino acid pattern among individual living organisms of the same species, and by the critical dependency of the racemization probability for an amino acid molecule on temperature, water concentration in the environment, alkalinity of the environment, association with other molecules (free state or a component of a macromolecule), size of the macromolecule of which it may be a component, specific location in the structure of a macromolecule, catalytic effect of clay surfaces with which it may be associated, presence of aldehydes and metal ions, concentration of buffer compounds in the environment, and ionic strength of the environment. In spite of these complications, fossils of similar characteristics, and which have experienced similar conditions of preservation, can be placed in a relative age sequence on the basis of D/L ratios. Due to the strong dependency of racemization rates on temperature, water concentration, and alkalinity, uncertainties regarding conditions of preservation can leave amino-acid-based age relationships among even similar fossils open to question. At the present time there is insufficient knowledge concerning the effective average racemization rate in a fossil as a function of time to justify dependence on D/L ratios for a quantitative determination of age.

The survival of amino acids in fossils from the Paleozoic era and the trend for the apparent racemization rate constant to decrease with conventional fossil age assignment raise a serious question concerning the accuracy with which radioisotope age data have been used to represent the real-time history of fossils.

The instability of the twenty amino acids which are the building blocks of proteins provides a possible means for determining the ages of fossils. A preliminary recognition of this possibility appeared in the scientific literature 30 years ago (Abelson 1955).

AMINO ACID SURVIVAL IN PHANEROZOIC FOSSILS

Since amino acids have widely varying degrees of stability, after the death of an organism the less stable amino acid components will decompose more rapidly than those which are more stable, producing an amino acid signature that is increasingly distributed toward the more stable components as time progresses (Hare & Abelson 1967, Lee et al. 1976, Akiyama & Wyckoff 1970). Because of the range of variation among individual members of the same species (Hare & Abelson 1965, Hare & Mitterer 1967, King & Hare 1972, Jope 1980), amino acids may be expected to provide at best only a broad indication of fossil age. Uncertainty as to the extent to which modern organisms represent in detail the characteristics of their ancient counterparts introduces additional lack of precision in a fossil age based on amino acid ratios.

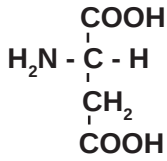
Amino acids have been reported from fossils distributed throughout the geologic column (Florkin 1969). Since detectable levels of many amino acids are expected to survive only a few million years, at best, these observations are an enigma (Abelson 1956, 1957). Therefore it has been suggested that the amino acids found in older fossils, such as those from Cambrian sediments, e.g., are recent contaminants rather than actual molecules remaining from the original organisms. Investigation of this suggestion has identified residual amino acids in Silurian graptolites (400-430 million year putative age) (Florkin 1969). It has been well established that shells as old as Jurassic (135-180 million year conventional age) may contain amino acids bound as protein and peptide, and hence residuals from the parent organisms (Akiyama & Wyckoff 1970). An attempt to account for these apparently anomalous observations has been made by suggesting that the fossil matrix somehow holds the amino acid molecules together so that they do not spontaneously decompose as would be expected on the basis of their binding energies (i.e., structural strength) (Hare & Mitterer 1968).

CHANGE OF D/L RATIO WITH TIME

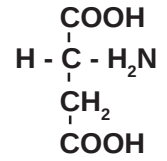
A far more suitable approach to fossil age determination is provided by the fact that all but one (glycine) of the amino acids in proteins are

asymmetric and may exist in either a left-handed (L) or a right-handed (D) form, each of which is the mirror image of the other. As an example, Figure 1 illustrates the L- and D-forms of aspartic acid. L- and D-forms have opposite rotational effects on the vibrational plane of polarized light. All other physical properties of the L- and D-forms of a given amino acid are identical, and of course the chemical compositions are identical. Small amounts of D-amino acids are found in organisms, but most of the amino acids in organisms are constituents of protein molecules, and *all* amino acids (except glycine which is symmetric and has no D- and L-configuration) in the protein of living organisms are in the L-configuration (Kvenvolden 1975).

Both the D- and the L-configurations of amino acids convert to the other over a period of time, either as the result of random thermal energy or through a catalyzed chemical mechanism. After the death of an



L - Aspartic Acid



D - Aspartic Acid

FIGURE 1. Structural Representation of Aspartic Acid Enantiomers.

organism the L-amino acids diminish while the D-forms accumulate until equilibrium conditions are reached. In the case of any amino acid containing a single asymmetric carbon atom, such as aspartic acid, the equilibrium state is 50% L- and 50% D-, a 1/1 ratio. After equilibrium is reached the conversion from D-to L- is just as rapid as the conversion from L- to D-. The equilibrium state is called a racemic mixture, and the process of approaching equilibrium is called racemization.

Four of the amino acids that make up proteins — isoleucine, threonine, hydroxyproline, and hydroxylysine — have two asymmetric carbon atoms which produce four structural possibilities for the same chemical composition. Two of these forms are designated as diastereomers, each of which may exist in either an L- or a D-form. Figure 2 illustrates this pattern for isoleucine, which together with aspartic acid has received the greatest attention in amino acid dating. Interaction among diastereomers is called epimerization. The epimerization process includes racemization.

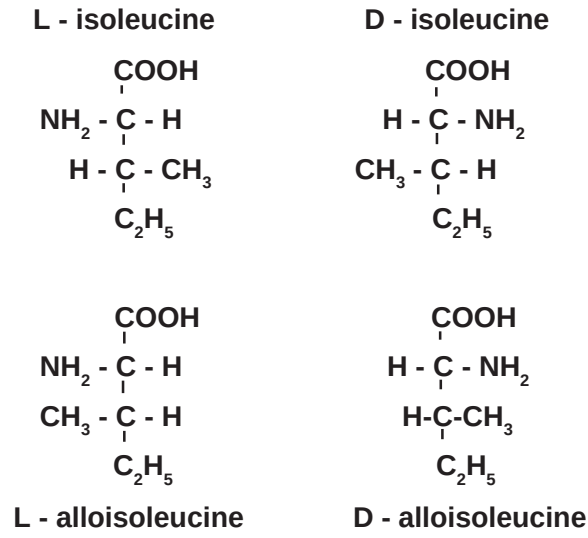


FIGURE 2. Structural Representation of Isoleucine/Alloisoleucine Enantiomers.

The racemic mixture resulting from the epimerization of isoleucine has been determined to have a ratio of D-alloisoleucine to L-isoleucine in the range 1.25/1 to 1.4/1, with greatest confidence in a figure near 1.25/1. For comparison of work done by different investigators 1.25/1 is accepted as a standard value (Kvenvolden 1975, Bada 1981, Wehmiller & Belknap 1982).

In contrast with age determination by ratios among the concentrations of various amino acids, age determination by D/L ratio has the advantage of a precise reference point, zero D/L ratio in the proteins of a living organism. The laboratory procedure involves only the measurement of two components that can be determined by standard chromatograph techniques with relatively inexpensive equipment. Before we can evaluate the results of such determinations we will need a relationship between the D/L ratio and time.

QUANTITATIVE RELATIONSHIPS FOR RACEMIZATION RATE

Let the symbols D and L now represent the concentrations of the D-form and the L-form, respectively, of an interconverting enantiomer pair such as D- and L-aspartic acid, or an interconverting diastereomer pair such as D-alloisoleucine and L-isoleucine. k_L will be the rate constant (probability) for conversion from the L-form to the D-form within a unit

of time, and k_D will be the corresponding rate constant (probability) for conversion from the D-form to the L-form. Symbolically

$$L \underset{k_D}{\overset{k_L}{\rightleftharpoons}} D$$

For the rate of change of L per unit time we can write

$$\frac{dL}{dt} = - k_L L + K_D D, \qquad (1)$$

where dL/dt is negative since the L-isomer experiences only a net decrease over time until dL/dt becomes zero at equilibrium. The integral solution of Equation (1) is (Bada & Schroeder 1972, Petit 1974)

$$\ln \left[\frac{1 + (d/L)}{1 - (k_D/k_L)\,(D/L)} \right] = \left[1 + (k_D/k_L) \right] k_L t + \text{Const.}, \qquad (2)$$

in which ln designates "natural logarithm." For enantiomer pairs such D- and L-aspartic acid which have equal concentrations of the L- and D-forms at equilibrium $k_L \doteq k_D \doteq K$. For aspartic acid Equation (2) becomes

$$\ln \left[\frac{1 + D/L}{1 - D/L} \right] = 2\, k_{asp}\, t + \text{Const.} \qquad (3)$$

For the diastereomer pair D-alloisoleucine and L-isoleucine with $k_L/k_D \doteq 1.25$, Equation (2) becomes

$$\ln \left[\frac{1 + (D/L)}{1\text{-}0.80\,(D/L)} \right] = 1.8\, k_{iso}\, t = \text{Const.} \qquad (4)$$

$k_L/k_D \doteq 1.25$ comes from the consideration that at equilibrium $k_L L = k_D D$, together with the accepted value of 1.25 for D/L at equilibrium. Although equations (3) and (4) appear complicated, they have the form of a simple straight-line relationship between two variables, as given by the type equation y = mx + b. The logarithmic term on the left corre-

sponds to the dependent variable y, and t corresponds to the independent variable x. The coefficient of t is presumed to be a constant, corresponding to m, and Const. corresponds to b. The Const. term in equations (3) and (4) is the value of the logarithmic term for zero fossil age (t = 0). Since the D-form does not exist in the amino acids of proteins in living organisms, the logarithmic term for t = 0 should be zero (ln 1 = 0), which specifies a zero value for Const. A non-zero constant term may be required to adjust for a slight racemization produced during the laboratory preparation of a sample (Bada & Shou 1980). This constant might not be the same for every laboratory, or for every procedure within a given laboratory.

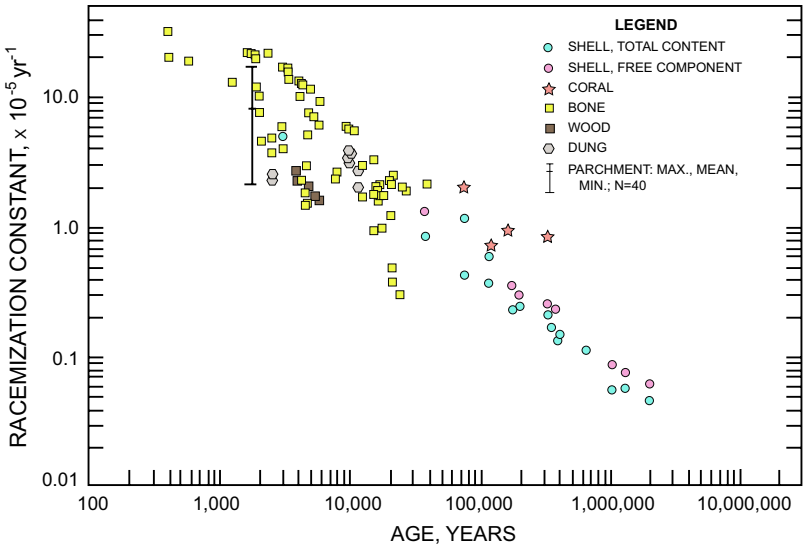
Isoleucine and alloisoleucine racemization rate constants reported in the literature are nearly always computed for Const. = 0 in Equation 4 (references for Figure 4). Aspartic acid racemization rate constants are commonly computed using Const. = 0.14 in Equation 3 (e.g., Schroeder & Bada 1973, Bada 1981). Four determinations of D-aspartic acid in modern packrat pellets (Petit 1974) specified 0.00, 0.040, 0.080 and 0.12 for this constant. A t = 0 constant of 0.06 has been adopted for the racemization of glutamic acid in a mollusk shell (Kvenvolden & Blunt 1980). Since a direct determination of the t = 0 constant is seldom reported in publications of D/L ratios for fossils, and since the 0.14 value commonly favored for aspartic acid yields physically unreasonable negative values of the racemization constant for all D/L ratios less than 0.070 (four such are encountered in the Dead Sea Scroll data that are included in Figure 3), all racemization rate constants plotted in figures (3) and (4) have been calculated on the basis of a zero value for the t = 0 constant.

To estimate the validity of using a zero t = 0 constant in computing the racemization rate constant values plotted in Figure 3, all the data sets represented in this figure were plotted as logarithmic term (y) against the fossil age (x). To the extent that Equation 3 is valid, and that valid real-time values for t are available, these plots should fit straight lines with a y-intercept equal to the appropriate t = 0 constant. Actually the plots indicate that there is a question concerning the validity of Equation 3 (i.e., that k does not have the same value for all fossil ages) and/or a question concerning the real-time significance of the assigned fossil ages, particularly those in excess of 15,000 years. Of the ten data sets which have a suitable spread of fossil age for a graphical determination of the t = 0 constant, seven are adequately described by a value of approximately zero, one requires a value in the range 0.6-0.9, one in the range 0-0.28,

and one in the range 0.04-0.19. Use of a value other than zero for Const. in Equation 3 would lower the k values plotted in Figure 3, increasingly as fossil age is reduced, and most conspicuously for fossil ages in the range below about 10,000 years; but would not alter the general conclusions to be discussed in the remainder of this paper.

Racemization rate constants cannot be determined theoretically, but must be calculated empirically from D/L ratio measurements made at two different times. Since racemization rate constants are so small under normal environmental circumstances, racemization may be accelerated by subjecting the sample to an interval of heating in a laboratory, with extrapolation from the rapid racemization and epimerization that occurs at elevated temperature to the much lower rate characteristic of the normal environment. An example of this temperature dependency is given by Equation (5) which specifies the racemization rate constant for isoleucine in foraminifera shell, expressed as chance per molecule per year in terms

FIGURE 3. Aspartic Acid Racemization Constant versus Associated Fossil Age. Data from Bada 1981, Bada & Deems 1975, Bada & Protsch 1973, Bada & Shou 1980, Bada et al. 1984, Bender 1974, Bischoff & Childers 1979, Kessels & Dugworth 1980, King & Bada 1979, Kvenvolden & Peterson 1973, Kvenvolden et al. 1973, Kvenvolden et al. 1979, Lajoie et al. 1980, Lee et al. 1975, Petit 1974, Schroeder & Bada 1973, Stafford et al. 1984, Wehmiller et al. 1976, Weiner et al. 1980, Zumberge et al. 1980.



of T in degrees Celsius (Centigrade) (Bada & Schroeder 1972, Wehmiller et al. 1976).

$$\ln k_{iso} = 36.31 - \frac{13675}{(273 + T)} \qquad (5)$$

According to this relationship a one-degree increase in temperature at 23ºC produces nearly 16% increase in the racemization rate.

In some cases rate constants extrapolated from high temperature racemization in the laboratory have produced an age estimate in satisfactory agreement with the accepted geochronologic age of a fossil (e.g., Hare & Mitterer 1968), but more often racemization rates based on laboratory or recent historical data yield fossil ages much less than the accepted geochronologic age. For example, amino acids with D/L ratios less than 1.00 have been found in Green River Formation (Wyoming) oil shale (Kvenvolden 1975). All amino acids from the organic material that produced the oil in this shale should have become racemic long before the 40-60 million years specified by the Eocene age of this formation. The apparent implication is that either the geochronologic age is incorrect or the samples were contaminated by recent organic material. Some fossil shells of Miocene age (10-25 million geochronologic years) have been reported to contain amino acids with a D/L ratio nearly equal to unity (Hare & Abelson 1967).

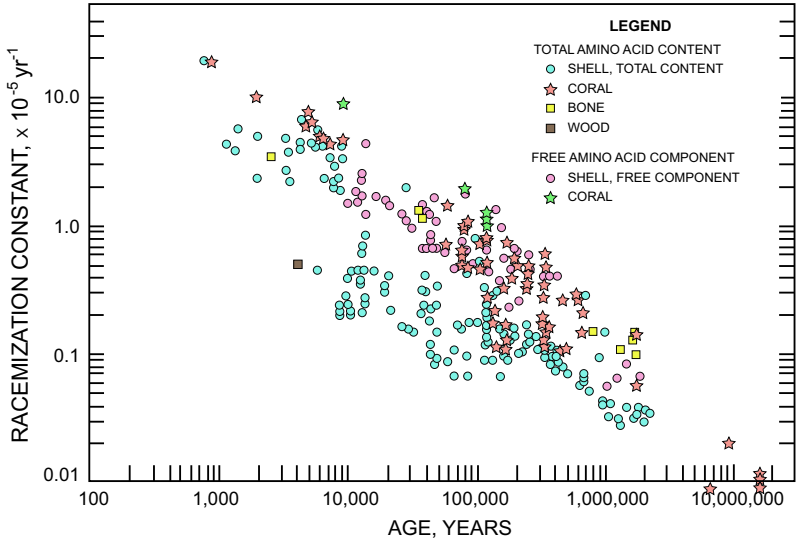
SUMMARY OF RACEMIZATION RATES IN RELATION TO FOSSIL AGE

Racemization rate constants for aspartic acid and for isoleucine, derived by equations (3) and (4) with zero t = 0 constant, from D/L ratio and associated fossil age data that have been published in the readily accessible literature, are plotted in figures (3) and (4). The four magnitude (10^4) range of data for both rate constant and age require a logarithmic scale on each axis. These data include mollusk shells, foraminifera shells, foraminifera ooze, coral, bones, wood, and parchment (Dead Sea Scrolls). With a few exceptions among ages in the less than 6000 years range, the age assignments are based on radiosotope data, either carbon-14 or disequilibrium of uranium daughter products. The specimens represented in figures (3) and (4) were obtained from a wide range of arctic, desert, temperate, and ocean floor environments. Some of them may have inconsistent age assignments.

The most impressive immediate impact of these plots is that for a particular amino acid there is no characteristic racemization rate constant that can be used to estimate the age of every fossil containing that amino acid. If each amino acid could be described by a characteristic racemization rate constant as a component of fossil protein, the data points in figures (3) and (4) would cluster about a horizontal line. The demonstrated clustering about a line which slopes downward indicates that the apparent racemization rate constant is actually not a constant, but is related to fossil age, diminishing as age increases. This observation has been made frequently in the literature (e.g., Lajoie et al. 1980, Bada & Schroeder 1972, King & Hare 1972, Wehmiller & Hare 1971, Hare & Mitterer 1966).

Given the sensitivity of racemization rate to temperature, could the general trend in figures (3) and (4) indicate that the older a fossil the lower the average storage temperature it has experienced? That is, do these data indicate that the mean temperature of the environment has

FIGURE 4. Isoleucine Racemization Rate Constant versus Associated Fossil Age. Data from Bada 1981, Bada & Protsch 1973, Bada & Schroeder 1972, Bada et al. 1973, Bischoff & Childers 1979, Blake 1980, Hare & Mitterer 1966, King & Neville 1977, Kvenvolden 1980, Kvenvolden et al. 1973, Lee et al. 1976, Masters & Bada 1977, Miller & Hare 1980, Mitterer 1975, Stafford et al. 1984, Szabo et al. 1981, Wehmiller 1977, Wehmiller & Hare 1971, Wehmiller et al. 1976.



been increasing over the time span covered by non-racemic D/L ratios? The isoleucine racemization rate in Figure 4 ranges from about 4×10^{-5} yr^{-1} to about 0.025×10^{-5} yr^{-1}, or about 160-fold, between fossil ages 3000 and 2,000,000 years. Using 7ºC as a mean annual temperature for modern times, Equation (5) specifies an effective average storage temperature of -19ºC for a 160-fold reduction. Due to the exponential dependency of racemization rate on temperature, the mean temperature during a large portion of the storage time would have to be lower than -19ºC to establish a -19ºC effective average between +7ºC and the beginning of storage. For 17ºC, rather than 7ºC, as a mean annual modern temperature, the corresponding effective average storage temperature would be -11ºC. These simplified estimates fully establish that the pattern of figures (3) and (4) cannot be explained on the basis of lower temperature on land and on the ocean floor in the past (Miller & Hare 1980, p 431). Other factors that may account for the pattern of figures (3) and (4) will be considered subsequently.

It has been asserted that amino acid age dating corroborates radiocarbon ages and age assignments based on disequilibrium of uranium decay products (e.g., King & Hare 1972, Bada & Deems 1975, Blake 1980). The basis for such claims may be illustrated from Figure 4. In Figure 4 a racemization rate constant in the vicinity of 0.2×10^{-5} yr^{-1} is associated with samples of assigned age ranging from about 10,000 years to about 700,000 years. Accordingly it is evident that a set of specimens can be obtained, or fortuitously acquired, for which a racemization rate constant derived from the D/L ratio in any one will predict the "correct" age when applied to any other member of the set. On the other hand, within the 10,000-700,000 year age range on Figure 4 one can select a sample set each of which has an assigned age of 80,000 years but has a racemization rate constant in the range between about 0.06×10^{-5} yr^{-1} and 2.0×10^{-5} yr^{-1}. For the Dead Sea Scrolls aspartic acid data set plotted in Figure 3 some samples located within one centimeter of each other on the same piece of parchment have D/L ratios that differ by factors of 1.7× to 3.9× (racemization rate constant ratios 1.8× to 4.0×) (Weiner et al. 1980).

With this simplified introduction to a highly complex topic one can appreciate the following comments from a paper presented at the 1978 conference on Advances in Biogeochemistry of Amino Acids (Miller & Hare 1980, p 416, 439): "...racemization 'dates' should probably be regarded only as preliminary estimates unless corroborated by other inde-

pendent criteria"; "Extrapolation based on ^{14}C dated samples to older samples must be considered tenuous...."

FACTORS AFFECTING RACEMIZATION RATE

From Figures (3) and (4) it is apparent that for any specific amino acid there is not one characteristic racemization rate constant that is appropriate for all ordinary circumstances at all times, as is the case for radioisotope dating. The racemization rate of an amino acid has been determined to be dependent on the following factors (Smith & Evans 1980, Kriausakul & Mitterer 1980a, 1980b).

1. Temperature
2. Water concentration in the environment
3. pH (acidity/alkalinity) in the environment
4. Bound state versus free state
5. Size of the macromolecule, if in a bound state
6. Specific location in the macromolecule, if in a bound state
7. Contact with clay surfaces (catalytic effect)
8. Presence of aldehydes, particularly when associated with metal ions
9. Concentration of buffer compounds
10. Ionic strength of the environment

Another complicating factor that may be encountered in the dating of bone and sediment without isolation of the bound amino acids from the free amino acids is the D-amino acid, particularly alanine, which may be produced by bacteria (Pollock & Kvenvolden 1978, Kessels & Dugworth 1980). This complication can be avoided by restricting analysis to amino acids or amino acid components which are unlikely to have been affected by bacteria, or to samples which do not contain excess amounts of the amino acids that are characteristic of bacterial activity.

It is apparent that any D/L ratio in a fossil represents both the age of the fossil and the environmental circumstances under which it has been preserved. If the significant environmental factors can be specified with certainty throughout the entire history of the fossil, the real-time age of the fossil can be derived from a D/L ratio and a corresponding racemization rate constant that has been determined for an equivalent environment. If the age is known, the rate constant derived from a D/L measurement might provide a significant intimation concerning the past

environment, e.g., paleotemperature (Bada et al. 1973, Schroeder & Bada 1973, Bender 1974, Mitterer 1975, Wehmiller 1977).

In consideration of the ten factors listed above, it is evident that equations (3) and (4) yield an effective average k that represents the combination of a large number of specific rate constants that have been descriptive of various individual amino acid molecules at different times throughout the history of a specimen. On the basis of this insight one can expect that during the early history of a fossil D-amino acids will accumulate relatively rapidly from L-molecules that may be described by a relatively high value of k, and that as time progresses accumulation will be increasingly limited to L-molecules associated with lower values of k. Such a model is the favored explanation for the pattern displayed in figures (3) and (4).

In relation to this model an investigation of the D-alloisoleucine/L-isoleucine ratio as a function of molecule size in protein from a Late Pleistocene *Mercenaria* shell (putative age in the 10-300 thousand year range) yielded the data in Table 1 (Kriausakul & Mitterer 1980a). On the basis of the D/L ratio for the total shell, from Figure 4 this shell could be assigned an age anywhere in the range between about 30,000 years and about 2,000,000 years. The maximum ratio of logarithms from column 3 is 53/1 (<500 fraction free, to 1000-10,000 fraction total). Whatever the age of this shell, the racemization rate constants would have a

TABLE 1

Racemization (Epimerization) in a Fossil *Mercenaria* Shell as a Function of Protein Molecule Size. Whole shell and molecular weight fraction <500 contain free amino acids, in addition to amino acids bound in protein molecules.

Protein Molecular Weight	D-alloisoleucine / L-isoleuceine		$\ln \frac{1 + (D/L)}{1 - 0.8\,(D/L)}$
>10,000	Total	0.067	0.1199
1000-10,000	Total	0.019	0.0341
500-1000	Total	0.095	0.1698
<500	Total	0.733	1.433
	Free	0.865	1.801
Whole Shell	Total	0.486	0.8884
	Free	0.819	1.663

corresponding ratio of 53/1. The highest ratio at any age in Figure 4 is 30/1 at 80,000 years. The ratio to be accounted for over the total range of fossil age in Figure 4 is about 2000/1. Since the observed range of variation in k at any particular fossil age is much less, and over the total range of fossil age is much greater, than the range allowed by the available data on racemization rate as a function of protein molecule size, explanation of the pattern displayed in figures (3) and (4) in terms of a progressive decline in the effective average value of k is at least questionable.

As an alternative to the model based on D-amino acid accumulation becoming increasingly limited to L-molecules initially associated with lower k, one could propose that as a fossil ages the breakdown of proteins continually renews the supply of L-molecules in locations with the higher values of k. If such were the case, the effective average value of k for the sample could be more nearly constant, rather than changing 2000-fold, as suggested by Figure 4, or 700-fold, as suggested by Figure 3. It is significant that temperature, water concentration, and alkalinity to which the racemization rate in a fossil is particularly sensitive are also factors which are particularly conducive to the breakdown of larger protein molecules to smaller components. Before conclusions may be drawn with confidence concerning change of the average racemization rate with time we should have studies such as that represented in Table 1 for each of several samples with well-determined fossil age assignments ranging from 5000 years to 1,000,000 years.

VALIDITY OF FOSSIL AGE ASSIGNMENTS

In a discussion of disagreement between fossil age as projected from amino acid D/L data and as based on radioisotope data, Bender (1974) has said "The differences [re ^{14}C age] can be reconciled if it is assumed that the ^{14}C age [of the sample under discussion] is wrong, but such an assertion would undermine other conclusions." With similar reasoning the progressive decline of racemization constants in figures (3) and (4) might be taken as an indication that the fossil age assignments are progressively excessive. This possibility is clearly indicated if the average probability for conversion of L-amino acids to the D-form in a sample actually remains roughly the same from century to century. Many difficulties would be resolved, and much anomalous data would be reconciled if fossil ages were adjusted to make the data points in figures (3) and (4) scatter about a horizontal line, rather than a line sloping downwards. While the data discussed in this paper provide an adequate

scientific basis for such an adjustment, the extent to which it "would undermine other conclusions" is a price very few members of the scientific community would be willing to pay. The course of preference is to assign the apparent inverse relationship between effective average racemization rate constant and fossil age to some time-dependent factor that is not yet fully understood.

To make the data points in figures (3) and (4) scatter about a horizontal line would require the reassignment of fossil ages approximately as indicated in Table 2. The rough estimates given in Table 2 are presented here for their possible interest, without any claim as to their significance. A more sophisticated data analysis would be required before such claims should be made.

TABLE 2

Approximate Fossil Age Reassignments Required to Produce Uniform Racemization Rate Constants (see text).

Current Fossil Age Assignment		40,000	100,000	350,000	1,000,000
Adjusted Fossil	Figure 3	6,000	11,000	18,000	8,000*
Age Assignment	Figure 4	5,000	14,000	18,000	14,000

*Insufficient data for comparison.

CONCLUSIONS

Thirty years of investigation into the potential for using amino acid data as indicators of fossil age has demonstrated that fossils of similar characteristics and which have experienced similar conditions of preservation can be placed in a *relative* age sequence on the basis of D/L ratios. Due to the strong dependency of racemization rates on temperature, water concentration, and alkalinity, uncertainties regarding conditions of preservation can leave age relationships among even similar fossils open to question. When age relationships can be established on a firm independent basis, in some cases D/L ratios can be a guide to paleotemperature.

At the present time there is insufficient knowledge concerning the effective average racemization rate in a sample as a function of time to justify dependence on D/L ratios for a quantitative determination of fossil age. The present status of amino acid dating can be summarized by the conclusion from the 19th International Symposium on Archeometry and Archaeological Prospection that "the time when [amino acid racemization]

can provide a problem-free dating service is still some way off" (Hedges 1979). The literature since 1979 indicates an increasing awareness of the uncertainties in using amino acid D/L ratios as indicators of age.

In addition to the wide range of fossil age associated with a given value of a racemization rate constant and the wide range of racemization rate constant associated with a given fossil age, there is a dominant trend for the effective racemization rate constant to decrease with putative fossil age. This relationship, together with the demonstrated survival of amino acids in fossils from the Paleozoic era, raises a question concerning the accuracy with which radioisotope age data have been used to represent the real-time history of fossils.

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ARTICLES

AN EVALUATION OF THE NUMERICAL VARIANTS OF THE CHRONOGENEALOGIES OF GENESIS 5 AND 11

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WHAT THIS ARTICLE IS ABOUT

The numerical data of the Septuagint text of the chronogenealogies of Genesis 5 and 11 are considered by some to have priority over that of the Masoretic text. The author outlines some impressive problems with that conclusion.

Although numerical variants are absent in all of the known manuscripts of the Masoretic text for both the antediluvian and postdiluvian periods, this is by no means the case for the Samaritan Pentateuch and the Septuagint, which have only one variant in the former to numerous variants in the latter.

These data have implications for schematization, as well as the choice of a representative manuscript or manuscript tradition as normative. If the Septuagint is to have priority over the Masoretic text, then one set of figures must be chosen as representative. The Codex Alexandrinus has usually been chosen for this purpose, since it is the oldest extant manuscript. However, older is not always necessarily better.

Due to the wide amount of variation in the numerical data, which point to their secondary character, and the obvious attempts at schematization in both the Septuagint and the Samaritan Pentateuch, it would seem that the Masoretic text, which has neither numerical variants or schematization, would be likely to preserve the figures closest to the original.

I. INTRODUCTION

In a previous article on the chronogenealogies of Genesis 5 and 11 (Hasel 1980, p 27-29, 34), our attention was directed to the fact that the numerical data of the Septuagint (LXX) and Samaritan Pentateuch are highly schematic, as opposed to the figures of the Masoretic text. I am in basic agreement with those conclusions, but in addition to the basic data which were pointed out (Hasel 1980, p 30-33),[1] I would like to focus more on the numerical variants in these texts (especially the LXX).

II. VARIATIONS IN THE MANUSCRIPTS OF THE LXX

Occasionally it has been argued that the LXX should have priority over the Masoretic text as far as the preservation of the original figures for a biblical chronology is concerned (Hales 1930, Shenkel 1968, Zurcher 1960). However, the adoption of the figures of the LXX has been found inadequate when applied to the chronology of the Hebrew Kings. There it

was found that the variants of the LXX resulted because of a failure on the part of the translators to understand the data of the Hebrew text. They, therefore, tried to correct the supposed errors (Thiele 1983, p 62, 90-94, 99, 209-210). The figures of the Masoretic text of the Books of Kings were found to be both internally and externally consistent as opposed to those of the LXX.

Unlike the chronology of the First Millennium B.C. which is relatively well known, there are no absolute dates or synchronisms whereby one can test which text preserves the original numbers for the period under discussion. This paucity of information makes it necessary to use such factors as schematization or its lack, and consistency or inconsistency of data as the primary indicators of priority.[2] The former has been dealt with previously (Hasel 1980) and so for the most part does not need to be readdressed.

As far as manuscript evidence concerning the numerical data are concerned, variants are absent in all of the known manuscripts (MSS) of the Masoretic text for both Genesis 5 and 11. Similarly there are no numerical variants for the Genesis 5 genealogy of the Samaritan Pentateuch, and only one for the genealogy of Genesis 11 in v 15.[3] In contrast to the above, the Septuagint exhibits a wide variety of variation in the numerical data. While the most widely known manuscript (MS) of the Septuagint (the Vaticanus — MS B) is missing for Genesis 1:1 - 46:28, and therefore yields no data here, there are numerous other MSS which prove the point (cf. the following tables).

Tables 1 and 3 give an overview of the numerical data for Genesis 5 and 11 respectively. The three major texts with the Alexandrinus (MS A) representing the Septuagint are compared. In addition the numerical variants which are found in the other Septuagint MSS are given. Because Josephus is sometimes viewed as a fourth line of evidence, he also has been included. Tables 2 and 4 list all of the Septuagint MSS where these numerical data may be found.

SIGLA

I. Texts

Aeth — Ethopic (Aeth ^{CFGMPR} - Editors of the Ethopic Text)
Arab — Arabic
Arm — Armenian (Arm ^{et} - Editors of the Armenian Text)
Bo — Bohairic
Co — Coptic
La — Old Latin (La^{AIX} - Editors of the Old Latin Text)
LXX — Septuagint
MT — Masoretic Text
Sa — Sahidic
Sam — Samaritan Pentateuch
Sy^{p,h} — Pishito and Harclensis (Syriac)

Syh — Syro-hexapla
Tar — Targum
Vulg — Vulgate
$\alpha^{'}$ — Aquila
$o\iota\lambda^{'}$ — The other translators (= Aquila, Symmachus and Theodotion)

II. **Uncials (Manuscripts Written in Upper Case Letters)**

$\aleph$ — Codex Sinaiticus (4th Cent. A.D.)
A — Codex Alexandrinus (5th Cent. A.D.)
B — Codex Vaticanus (4th Cent. A.D.)
D — Codex Cottonianus (5-6th Cent. A.D.)
D^{G} — Grabe collation of D (in H. Owen, 1778)
D — (in the NT cf. n. l.) - Codex Bezae (5-6th Cent. A.D.)
M — Codex Coislinianus (7th Cent. A.D.)
N — Codex Basiliano - Vaticanus (8th Cent. A.D.)
θ — (NT) Codex koridethi (9th Cent. A.D.)
ψ — (NT) Codex Athous Laurae (8-9th Cent. A.D.)

III. **Minuscules (Manuscripts Written in Lower Case Letters)**

in numerical order from 1-800 in Gottingen edition of the LXX
a — e_2 in alphabetical order in Cambridge edition of the LXX
17' (e.g.,) = 2 MSS (17' = MSS 17 + 400)

IV. **Manuscript Families**

C´' — Catena Group
$C^{'\text{-}18}$ (e.g.) — all MSS in this group except the following
f^{13} (NT)=MSS 13, 69, 124, 174, 230, 346, 543, 788, 826, 828, 983 and 1689
O — O Recension (MSS based on Origen's Hexapla)
other text families: -bdfnstyz

V. **Papyri**

in numerical order from 801-999
p^{75} (NT cf. n. 1.) - Bodmer Papyrus (early 3rd Cent. A.D.)

VI. **Other Manuscripts**

B — Δab - (cf. n. 3) - MSS of the Samaritan Pentateuch

VII. **Church Fathers**

Aug — Augustine (*Quaesti*ones de Genesi)
Chr — Chrysostom (I-VIII)
Cyr — Cyril of Alexandria (Alexandrius II)
Epiph — Epiphanius Latinus (*De Mensuris*)
Eus — Eusebius (Caesariensis IV)
lat — Latin Church Fathers
Or — Origen (*Sel*ecta in Genesim)
Qlul Hil — Quintus Iulius Hilarianus (De *Cursu* Temporum)

VIII. **Other Ancient Witnesses**

Jos — Josephus

IX. **Symbols**

c — corrector
c pr m — corrected by original writer
mg — margin
MS(S) — Manuscript(s)
om — omit
pr m — original writer
rell — remaining MSS
sic — an abnormality exactly reproduced from the original
txt — text
(vid) — it would seem
* — original
$\mathfrak{M}$ — majority reading
$\otimes$ — Hexaplaric asterisk
( ) — e.g., (D) - only a portion of the v(v). of the following MS(S)

TABLE 1

Textual Variations of the Numerical Data of Genesis 5

Figures are the years given in a particular verse (left column) for particular text (listed at the top). See Sigla table for symbols. Primary data as given by Ellinger & Rudolph (1977, p 7-8); Von Gall (1918, p 7-9); Josephus Antiquities (i:3:4); and Wevers (1974, p 102-108).

Verse	MT	Sam.	Jos.	LXX[A]		Variants of LXX		
3	130	130	230	230	130	330		
4	800	800	—	700	200	705	800	
5	930	930	930	930	230			
6	105	105	205	205	105	135		
7	807	807	—	707	700	807		
8	912	912	912	912	902	910		
9	90	90	190	90[txt]/190[mg]	90	95	110	140
10	815	815	—	715	15	705	815	915
11	905	905	905	905	825	915	925	
12	70	70	170	170	70	180		
13	840	840	—	740	840			
14	910	910	910	910	710			
15	65	65	165	165	65	160		
16	830	830	—	730	700	704	830	1000
17	895	895	895	895	795	805	890	905
18	162	62	162	162	192			
19	800	785	—	800	700	785		
20	962	847	962/969	962	162	840	847	965
21	65	65	165	165	65	162		
22	300	300	—	200	300			
23	365	365	365	365				
25	187	67	187	167*/187[c]	165	167	177	
26	782	653	—	802*(vid)/782[c]	300	802		
27	969	720	969	969	949	965		
28	182	53	182/188	188	148	180	182	
30	595	600	—	565	560			
31	777	653	707/777	753	780	853	733	755
							553	953
						777	843	753
							773	747
32	500	500	500	500	700			

TABLE 2

Septuagint Manuscripts of Genesis 5

Letters and numbers refer to different manuscripts with the variant given at the left. See Sigla table for symbols. Primary data as given by Wevers (1974, p 102-108).

Verse	Variant	Manuscript
3	230	A, D, M, 17', 135', C´'-18, 75, s, 121, 346, 392, 730, 318, z-31, 55*, 319, 509, 59, Cyr II 44, Eus IV 25
	130	344, Syh, οιλ[l], 135
	330	424, 31
4	700	A, D[G], M, 911, 17', 376, C´'-18, 730, s, t, y-424', z-31, 55, 59, 319, 509
	200	129[txt]
	705	135
	800	344, οιλ[l]
5	930	A, D[(vid)], M, 911[(vid)], 17', 135, 376, C´'-18, 75, 730, s, t, y-527, 71, 318, z, 55, 59, 319, 509, α[l], Epiph *De Mensuris*, 159
	230	129*, 53
6	205	A, M, 17', 135', C´'-18, 75, 730, s, t, 318, y-527, z, 55, 59, 319, 509, Cyr II 45
	105	135, Syh, οιλ[l]

Verse	Variant	Manuscript
	135	344', οιλ^{l}
7	707	A, M, 911$^{(vid)}$, 17, 135, 16, C´$^{\prime\text{-}18}$, 75, 346, 730, s, 318, 71, 121, 392, 424, z^{-31}, 55, 59, 319, 509, Syh ⊗
	700	31
	807	135, s^{-343}, οιλ^{l}
8	912	A, 911$^{(vid)}$, 426, 17', 135', d, 44, 127, t^{-799}, 318, 319, 129, 54, Syh ⊗
	910	M, 422, C´$^{\prime\text{-}16,18}$, 408, 19', 730, 71, 392, 424, 121, z, 55, 59, 509, Cyr II 45, Aeth^{P}
	902	18, 130*
9	190	A^{mg}, 911$^{(vid)}$, C´$^{\prime\text{-}16,18,79}$, 318, 509, 135
	95	s^{-343}, οιλ^{l}
	90	A^{txt}, 53, 135, ^{lat}QIul Hil*Curs* CLIX 5, Vulg, οιλ^{l}
	110	426
	140	75
10	715	A, M, 911$^{(vid)}$, 376, 17', 16, 75, 130, s, t, 318, 346, 71, 121, 392, 424, z, 55, 59, 319, 509, Syh
	915	14, 77', 128^{txt}, 414*, 422, 500, 551, 739*, 73', 413, 550*
	705	135
	815	s^{-343}, οιλ^{l}
	15	53, 664
11	905	A, D^{G}, M, 911$^{(vid)}$, 17', 135', 16, 75, s, t, 76*, 318, 392, 346, 71, 121, 424, z, 55, 59, 319, 509, Cyr II 45, Syh
	915	73^{c}, 550*, 54
	925	664*, 53'
	825	426
12	170	A, M, 911$^{(vid)}$, 901, 400, 17', 135', s, 16, 500, C´$^{\prime\text{-}18}$, 75, 130, 730, 318, 346, 121, 424, 71, 392, 31', 120', 55, 59, 319, 509, Cyr II 45
	180	d, 527
	70	53'
13	740	A, M, 17', 135', 16, C´$^{\prime\text{-}18}$, 75, 130, 730, s, 71, 392, 318, 121, 424, 346, 31', 120', 319, 55, 509, Syh
	840	s^{-343}, οιλ^{l}
14	910	A, M, 17', 135', 16, 422, C´$^{\prime\text{-}18}$, 75, 130, 730, s, 76*, t, 121, 318, 346, 71, 392, 424, 31', 120^{mg}, 55, 59, 319, 509, Cyr II 45
	710	120^{txt}, 407
15	165	A, M, 911$^{(vid)}$, 400*, 17', 135', C´$^{\prime\text{-}18}$, 75, 78, 730, 71, 318, 346, s, 121, 392, 424, z, 55, 59, 319, 509, Cyr II 45, Syh
	160	707
	65	53, 664^{c}, s^{-343}, οιλ^{l}
16	730	A, M, 911$^{(vid)}$, 135^{c}, 17', 16, C´$^{\prime\text{-}18}$, 52^{c}, 56^{mg}, s, 730, 318, y^{-527}, z, 55, 59, 319, 509, Syh
	704	72
	700	56^{txt}
	1000	130*$^{c\ pr\ m}$, 135*
	830	52*, s^{-343}, οιλ^{l}
17	895	A, M, 135, 17', 376, 16, 75, 343, s, 318, 424, 346, 121, 31, z, 55, 551, 319, 509, Cyr II 45, Syh
	795	C´$^{\prime\text{-}16,18,313c,413,551',646,739}$, 392, 730, 79
	905	107
	805	125, 59*$^{(c\ pr\ m)}$
	890	246
18	162	A, D, M, 17', 135, 376, 16, C´$^{\prime\text{-}18}$, 550^{c}, 75, 130, 730, s, 318, 346, 121, 392, 424, z, 55, 319, 509, Cyr II 45, Syh
	192	550*
19	800	A, M, 17', 135', C´$^{\prime\text{-}16,18,500}$, n, 730, y$^{-346'}$, z, 55, 59, 319, 509
	785	130$^{(vid)}$, 344'
	700	53'
20	962	A, D, M, 911$^{(vid)}$, 135, 17', 376, 16, 25, C´$^{\prime\text{-}18}$, 73, 75, 569, s, 130, 730, 392, 318, 79, 121, 346, 424, 31', 120, 55, 509, 319, Syh
	162	646*

Verse	Variant	Manuscript
	847	344', οιλ^{l}
	840	130
	965	54
21	165	A, D, M^{mg}, 911$^{(vid)}$, 17', 135', C$^{'1-18}$, 53, 75, s, 730, t^{-799}, 318, y^{-527}, z, 55, 319, 509, Syh
	65	M^{txt}, 54, 344, οιλ^{l}
	162	664
22	200	A, M, 911$^{(vid)}$, 17', 135', C$^{'1-16,18}$, 413, n, 730, t^{-799}, y^{-527}, z, 55, 59, 319, 509
	300	344, οιλ^{l}
23	365	A, D$^{(vid)}$, M, 17', 135', C$^{'1-18}$, 75, 730, s, 71, 318, y^{-527}, z, 55, 59, 319, 509, Syh
25	167	A*, 911$^{(vid)}$, 17', 135', C$^{'1-16,313c}$, 370, 730, 318, 346, 319, Syh
	187	A^{c}, D, M, 15, 64, 707, 16, 458, 121, 392, 424, 71, 31', 55, 59, 509, 313^{c}, s^{-127*}, z, Chr VII 181, Syh, οιλ^{l}, Aeth^{-M}, Arab, Tar
	165	d, 527, Sa
	177	75, 127*$^{(vid)}$
26	802	A*$^{(vid)}$, 911$^{(vid)}$, 17', 135', 318, 346, 408^{c}, 319
	782	A^{c}, D^{G}, M, 15, 64, 707, C$^{'1-408c}$, 246, 458, 75, s, 730, 71, 121, 392, 424, z, 55, 59, 509, Aeth^{-P}, Arab, Arm^{et}, Syh
	300	130, οιλ^{l}
27	969	A, M, 911$^{(vid)}$, 17', 135', C$^{'1-57c,646}$, 52, 458, n, s, 730, 71, 318, 121, 346, 392, 424, 120', 31', 55, 59, 319, 509, 130, οιλ^{l}, Syh
	965	82
	949	646, 57^{c}
28	188	A, D, M, 911$^{(vid)}$, 17', 135', C$^{'1}$, s, 730, t, 121, 346, 392, 424, 318, 71, z, 55, 59, 319, 509, Or *Sel* 104, Chr VIII 629, Syh
	180	458, 75, Chr VII 181
	148	Sa
	182	Aeth^{G}, Arab, Tar
30	565	A, M, 911$^{(vid)}$, 17', 135, C$^{'1}$, 761, 314, 75, s^{-130}, 730, 76', 134, 799, 346, 392, 318, 376, 424, 71, 121^{mg}, 31', 120', 55, 59, 319, 509, Or *Sel* 104, Syh
	560	121^{txt}
31	753	A, M, 376, 17', 135', C$^{'1}$, n, 130$^{(vid)}$, s^{-344mg}, 730, 799, t, 346, 392, 121, 424, 31', 120, 55, 59, 319, 509, Or *Sel* 104, Syh
	853	911$^{(vid)}$
	780	72
	755	707, 19', d, 527
	953	318
	733	71
	553	54
	653	344
	777	Arab, Tar
	743	Aeth^{CR}
	773	Aeth^{FG}
	747	Aeth^{-P}
32	500	A, 17', 135', 44*, 319
	700	108*

TABLE 3

Textual Variations of the Numerical Data of Genesis 11

Primary data as given by Ellinger & Rudolph (1977, p 15-17); Von Gall (1918, p 17-18); Josephus Antiquities (i:6:5); and Wevers (1974, p 143-149).

Verse	MT	Sam.	Jos.	LXX^{A}		Variants of LXX
10	100	100	—	100		
10	2	2	12	2		
11	500	500	—	500	355	

Verse	MT	Sam.	Jos.	LXX[A]	Variants of LXX						
12	35	135	135	135	35						
13	403	303	—	430	130	330					
13	—	—	—	130	135	139					
13	—	—	—	330	403	430					
14	30	130	130	130	30						
15	403	303/330	—	330	303	313	350	403	430	450	
16	34	134	134	134	34	104	140	170			
17	430	270	—	370	209	270	279	330	430	600	
18	30	130	130	130	30	134	135	140	170		
19	209	109	—	209	208	250	270	207			
20	32	132	130	132	32						
21	207	107	—	207	107	700					
22	30	130	132	130	30	135					
23	200	100	—	200	70	100					
24	29	79	28/29/79/120	79	29	70	130	179	209		
25	119	69	—	129	22	29	119	122	125	200	229
26	70	70	70	70	109	175	400				
32	205	145	205	205	5	75	250				

TABLE 4

Septuagint Manuscripts of Genesis 11

Primary data as given by Wevers (1974, p 143-149).

Verse	Variant	Manuscript
11	500	A, D^{G}, M, 911, 961, $O^{-15,72',426}$, C´', n, t, 55, 59, 319, 509, 121*, 318, 392'
	335	619, z, 121^{c}, 424
12	135	A, D, M, 911, 17, 376, 400, 82, 135, 14, C´', 313, 18, 129, 246, n, 458, s^{-343}, t, y, 346', 392, 31', 120, 833, 55, 319, 509^{mg}
	35	53', 509^{txt}, Tar
13a	430	A, 52, b, d, 343, 121*, 318, La^{A}, Aeth, $Arab^{mg}$, Sa
	330	M, 135, 17', $C^{'1-25*,52,551',569}$, 458, $75^{c\ pr\ m}$, 527, $Arab^{txt}$, Bo, ^{lat}Aug *Quaest* 23, rell
	130	569, 75*
13b	130	A, M, 911, 75, 130, 121, 392, 346', 120, 833, 31', 55, 59, 319^{mg}, 509^{mg}
	139	d, t, 15, 17', 135, 426, 54, 129, 246, 343, 318, Sa^{19}
	135	458
13c	330	A, 911, 961, 833, 458, 130, 346
	403	319, 376, 53', 82
	430	M, $319^{c\ pr\ m}$, 17', 135, 426, d, n, 392, 54, 55, 527, La^{X}, Co, $Aeth^{-P}$
14	130	A, M, 911, 961, 82, 135, 17', 376, C´', 569, 129, 246, 458, n, s^{-343}, t, 318, 424, 121, 392, 346', 31, 122, 120', 833, 55, 59, 509, $319^{c\ pr\ m}$
	30	53', Tar
15	330	A, D^{G}, M, 17', 135, 75, 121, 424, 527, 31', 833
	313	911^{sic}
	303	961, 458, 318, Sa
	350	707, 72, C´', s^{-343}, 730, 59, 346
	403	82, 376, 319, 53', Tar
	430	120', La^{X}, $Aeth^{C}$
	450	509
16	134	A, M, 911, 961, 82, 135', $C^{'1-25,408*}$, 78, 129, 17', 246, 75, 130, s^{-343}, t, 121, 318, 424, 392, 31', 346', 407, 833, 509, 55, 59, 319^{c}

Verse	Variant	Manuscript
	140	25
	170	408*, 120
	104	458
	34	319*, 53', Tar
17	370	A, 911, 31$^{pr\ m}$
	270	M, 961, 72, C´', 18, 129, 246, 458, n, 833, 346', 46, t, 318, 730, s^{-343}, 59, 55, 509, Arm, Sa, Bo
	209	17, 135, 54, d, 15, 426
	279	392
	330	53, 664*, Arab
	430	82, 376, 664^{c}, Aeth^{C}, Tar, 319, 120'
	600	707
18	130	A, M, 911, 75, 121, 318, 122, 833, 319^{c}, 376, 31, C´', 313^{mg}, y, s^{-343}, 55, 59, 509
	134	961, 135, 17', b, d, t^{-46}, 615', 52', 54, 569, 15, Arm, Sa
	30	82, 53', 319*, Tar, Sa^{20}
	135	458, 120'
	140	46
	170	408
19	209	A, M, 911, 961, 17', n, 135', 122, 458, s^{-343}, t, 121, 318, 346', 392, 424, z, 82, 833, 319, 55, 59, 509, 313^{mg}
	208	C´'$^{-422,551'}$, 52
	250	422, 551'
	270	Bo
	207	246
	om	408*, 761
20	132	A, M, 911$^{(vid)}$, 17', 135', C´', 79, 129, 246, 458, t, 75, s^{-343}, 46, 121, 346', 424, 31, 122, 120', 833, 392, 319^{c}, 55, 59, 509
	32	82, 53', 318, 319*, Tar
21	207	A, M, 911, 961, 135', 17', 82, C´'$^{-18}$, n, s^{-343}, t, 392', 424, 121, 318, 619, 31', 120', 833, 55, 59, 319, 509
	107	Arab^{txt}
	700	346
22	130	A, M, 911, 961, 135', C´', 54, s^{-343}, t, 121, 424, 346', 392, 31', 120', 833, 55, 59, 319^{c}
	30	17', 82, 16, 53, 664$^{(vid)}$, 319*, Tar
	135	129, 246, Aeth^{-C}
23	200	A, 17', 82, 135', C´', 75, t, 392, 120', 55, 59, 319, 509
	70	707
	100	Arab^{txt}
24	79	A, M, 961, 17', 135', C´', s^{-343}, 46, t, 346', 392, 120', 509, 55, 319^{c}, 911$^{(vid)}$
	29	82, 376^{txt}, 319*, Tar
	70	72'
	130	Sa^{19}
	179	19', 343, Aeth
	209	376$^{mg\ (vid)}$
25	129	A, M, 911, C´'$^{-l8,414'}$, 75, s^{-343}, 346', 392, 120', 31, 833, 25, 55, 59^{c}, 509, 77
	29	422$^{txt\ (mg\ inc),414}$
	119	82, 376, 319, 53', Arab, Tar
	122	961, 15, 426, 17 ‘, 135, 54, d^{-44}, 129, 343, Arm
	125	b
	229	458
	22	44
	200	59*
26	70	A, M, 911*$^{c\ pr\ m}$, 961, 17', 82, 135', 414, C´'$^{-422}$, 551*, 129, 246, t, y$^{-346,619}$, z, 55, 59, 319, 509
	109	75
	175	458

Verse	Variant	Manuscript
	400	707*
32	205	A, M, 15', 376, 121, 53, 458, n, 344', t^{-134}, $C^{'-569}$, 318, 424, 346, 392', 122, 120', 833, 55, 59, 319, 509, La^{A}
	5	135
	75	569, 44, 129
	250	134

III. IMPLICATIONS OF THE DATA

As can be seen from Tables 1 and 3, there is at least one variation for each verse among the Septuagint MSS, with the two exceptions of Genesis 5:23 and 11:10a. It is interesting to note that with only these two exceptions there is total agreement among all of the authorities cited concerning the age of Enoch when he was translated and the age of Shem when he became the father of Arpachshad. There is not quite total agreement on the birth of Arpachshad occurring two years after the flood.

It can be seen from the above that if the LXX chronology is chosen to have priority over the others, one must decide which LXX MS (or perhaps MS tradition) is to betaken as normative. Of the three major codices (MSS ÀAB), only the Alexandrinus (MS A) is extant for this part of Genesis, and even for it, there are three variations (Genesis 5:9, 25-26, cf. Tables 1 and 2). It has been suggested that the LXX chronology is confirmed by Josephus because his data are nearly the same (Zurcher 1960, p 60). However, in addition to the arguments against that position (Hasel 1980, p 26-27), the question arises as to which MS it confirms. The Alexandrinus comes close, but even if that were the case, an agreement between two sources does not necessarily prove originality. The MSS of Josephus also contain several variants (cf. Tables 1 and 3) of their own.

It has recently been suggested that the Samaritan Pentateuch preserves the oldest account of the figures, at least for the antediluvian period, because the flood date for it and the Book of Jubilees[4] is the same. Further, it is said that in their extant forms, all three ancient sources (MT, LXX and Sam) are schematized, thus leaving the question of priority open (Johns 1984, p 14). However, the chronology before the flood in the Book of Jubilees has been demonstrated to be based largely on the Samaritan Pentateuch, although certain postflood figures are dependent upon the LXX (cf. Cassuto 1961 in Hasel 1980, p 27, 31). It also seems somewhat precarious to base such conclusions on a highly schematized source (the Book of Jubilees) to confirm the data of an earlier text (the Samaritan Pentateuch) to which it was dependent in the first place.

In comparing the texts, it is interesting to note that the Samaritan Pentateuch agrees with the Masoretic text 19 out of 28 times for the antediluvian period (cf. Table 1). Only with Jared, Methuselah and Lamech are the data changed in order to make all three die in the year of the flood. That this was the case seems rather improbable, with the exception of the death of Methuselah whose name might indicate this. In contrast, there is only a 4 out of 19 agreement between the same two texts for the postdiluvian period (cf. Table 3). It is possible that the large difference reflects an attempt to make this genealogy more symmetrical with its counterpart in chapter 5, thus making the deaths of these patriarchs occur in the approximate order of their births, instead of Abraham being partly contemporary with most of his preceding postflood ancestors from Shem on, as in the Masoretic text.

Given such a wide variation in the data of the LXX MSS, it is most instructive to make comparisons between texts while choosing one as representative. The Alexandrinus, the earliest extant MS,[5] is usually chosen for this purpose; however, the earliest extant MSS are not always the best or most original. It is true that many times the majority of MSS follow the numerical data given by this early MS. However, this is by no means consistent.[6] Schematization on the part of the LXX is thus multiplied, in that the scribes either misunderstood earlier MSS or, endeavoring to correct what was felt to be erroneous, developed their own. The reason for the original scheme remains unknown.[7]

IV. CONCLUSION

It would appear from the foregoing analysis that the chronogenealogies of Genesis 5 and 11 in both the Septuagint and the Samaritan Pentateuch are inconsistent due to textual variants in the numerical data to one degree or another, as well as various forms of schematization. The wide variation in the LXX MSS, which may also point to a variety of views concerning scheme, appears to mitigate against it as the most popular alternative to the Masoretic chronology which in contrast has no variant readings of the numerical data in all of the known MSS, nor reveals any kind of scheme. It would therefore seem that at present the evidence points to the Masoretic text as preserving the figures closest to the original.

ENDNOTES

1. The second Cainan of Genesis 11:12-13 (LXX) occurs in MSS A, (D), M, 833, (911,961), $O^{-58,82,376}$, $C^{\prime\prime-646}$, b, d, $f^{-53',56}$, n, s, t, y^{-71}, z (407), 55, 59, 319^{mg}, 509 and Sa. MSS which omit him are 82, 376, 53', 319^{txt} (c pr m) and Arm. In the Table of Nations in Genesis 10:24, MSS which include him are A, M, 72', C´´, 108, 121, s^{-343}, 55, 730, and La^{l}. MSS

which omit him are p^{833}, $p^{91\,1}$, p^{961}, $O^{-72'}$, 108, d, f, n, 343, t, y^{-71}, 619, z^{-407}, 59, 319 and 509. In 1 Chronicles 1:24 (18), MSS which include him are A, N, a-f, i, (sub ⊗), j-z, e_2 and Arm. MSS which omit him are B, g, h, c_2 and Syh. In Luke 3:36, MSS which include him are A, θ, ψ, 0102, f^{13} (565), $\mathfrak{R}$ $Sy^{p.h.}$. MSS which omit him are D and $p^{75\,(vid)}$. (Wevers 1974, p 138, 144; Brooke et al. 1932, p 392; and Nestle et al. 1979, p 163).

2. The author is aware that the lack of variants in the Masoretic text and the Samaritan Pentateuch may represent the repression of earlier MSS which deviate from them. This would indicate the possibility that we do not have the original numerical data in any of the extant texts. However, it is felt here that the Texts and MSS which we do possess are primary, and that these ought to be dealt with in their own right, rather than developing a hypothetical set of numbers which may or may not have been in their precursors.
3. The number 303 is found in MSS B, C, E^2, G^1, I, N, P, Q, W^1, X^2, $\mathcal{B}$, $\mathcal{D}$, $\mathcal{E}$, $\mathcal{G}$, $\mathcal{F}$ϕΔab. The variant 330 is found in MS $\mathcal{A}$ (Von Gall 1918, p 17); cf. Table 3.
4. The Book of Jubilees consists of a schematized chronology of 50 Jubilees (i.e., 49 year periods) from Creation to the Exodus which total 2,450 years. It is based on the solar calendar as opposed to the then prevalent lunar calendar.
5. MS p^{911} is earlier by a century and a half, but is incomplete and contains many lacunae.
6. The numbers given here for the LXX MSS in Tables 1-4 reflect only the numerical value, and do not differentiate between the order of elements (e.g., 188 in Genesis 5:28 appears in the various MSS as 100/80/8 years; 8 and 80 and 100 years; years 100/80/8; years 100 and 80 and 8). This variation in the order of the elements would further indicate their secondary character.
7. The suggestion that the LXX chronology resulted as a response to the Egyptian chronology of Manetho is inadequate. The modern scheme is dated to about 3000 B.C. However, Manetho's actual figures total 5471 years by dead reckoning, from the First Dynasty to the conquering of Egypt by Alexander the Great, a figure which was assumed as fairly accurate until recently (Gardiner 1961, p 61).

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NEWS AND COMMENTS

THE LOUISIANA BALANCED-TREATMENT ACT

While Judge William R. Overton's decision in January 1982 against the Arkansas law requiring equal time for creation in public-school science classes was being hailed by evolutionists as a stunning defeat for creationist legislation, supporters of balanced-treatment laws merely transferred their energies to the State of Louisiana where in 1981 the legislature had passed a Balanced Treatment for Creation-Science and Evolution-Science Act to begin in September 1982.

Although the teaching of origins was not compulsory, the Act required the inclusion of scientific evidence and related inferences for creation-science (e.g., the abrupt appearance of complex living forms in the fossil record and the systematic gaps between fossil forms) whenever scientific evidence and related inferences for evolution were presented in the science classes. A panel of seven creation-scientists, appointed by the governor, would advise local school districts on the appropriate curriculum. The Act neither required nor allowed instruction in any religious doctrine or material, and the vaguer terms of the new law made it less vulnerable to legal challenge.

The Act faced formidable opponents. The Louisiana Department of Education, the Superintendent of Education, the Board of Elementary and Secondary Education (BESE) and its members refused to implement it, because they believed it to be a thinly veiled disguise for the fundamental Christian view of creation and therefore a violation of the First Amendment principle of separation of church and state.

On December 2, 1981, forty-four state legislators, scientists (including an agnostic evolutionist who believed that both views should be taught), educators, spokesmen for Christian, Jewish and Muslim faiths, concerned parents and students filed a lawsuit [*Keith v. Louisiana Department of Education* (No. 81-989B)] in the U.S. District Court in Baton Rouge, Louisiana, asking for a declaratory judgment that the Act was constitutional. The lawsuit argued that balanced treatment of creation along with evolution did not violate the First Amendment, because the law required only the presentation of *scientific* evidence on the subject of origins, and neither did it violate academic freedom, because it gave students a choice between the explanations.

State Attorney General William J. Guste, Jr., appointed constitutional lawyers Wendell R. Bird and John W. Whitehead (whose services had been refused by the State of Arkansas) as lead counsels to take depositions and to argue the case at trial. They hoped to be able to make many constitutional arguments that had either not been made at all or that were inadequately supported by testimony at the Arkansas trial. One creationist newsletter stated: "We are optimistic that the Louisiana lawsuit will result in a judicial opinion that public school instruction in creation-science is constitutional, directly contrary to the

Arkansas decision, because it involves a different statute, new and different arguments and support, different expert witnesses, new and different scientific evidence, a-different legislative purpose, and an adequate defense" (*Acts and Facts* Impact Series #105, p iv).

This lawsuit was only the beginning of protracted legal maneuvers by supporters and opponents. The following day, the American Civil Liberties Union (ACLU) filed an action in the U.S. District Court in New Orleans, challenging the law's constitutionality, requesting permission to add new intervenors to attack the law, and asking for a dismissal of the lawsuit filed the previous day. In response, state-deputized attorneys filed a motion, along with 200 pages of briefs and accompanying materials, to stay or dismiss the ACLU suit on the basis of the pending suit in Baton Rouge. Attorney General Guste commented that the ACLU was "seeking to censor scientific information with which it disagrees."

Now there were two lawsuits over the same law. On March 9, 1982 in Baton Rouge Federal Judge Frank J. Polozola denied the ACLU's motion to intervene in the case and to dismiss it. In New Orleans on March 19 Federal Judge Adrian Duplantier ordered a stay of the ACLU suit. The trial date was set for July 26 - August 6 in the U.S. District Court in Baton Rouge.

On June 28 the U.S. District Court in Baton Rouge dismissed the case, and the battleground over the constitutionality of the Balanced-Treatment Act moved to the U.S. District Court in New Orleans. The case [Aquillard v. Edwards] was rescheduled to 1983.

Meanwhile, the Louisiana BESE and the ACLU moved for summary judgment (an immediate decision on some of the issues before a trial or on all of the issues without a trial), arguing that the Louisiana constitution allowed only the BESE to make educational policy and that the Balanced-Treatment Act violated this delegation of authority. Judge Duplantier agreed and ruled the Balanced-Treatment Act to be unconstitutional.

Duplantier's ruling was immediately appealed to the U.S. Court of Appeals for the Fifth Circuit. On January 31, 1983 the motion to certify the question to the Louisiana Supreme Court was granted. On April 1 the Louisiana Supreme Court accepted certification and granted the attorneys' motion for the opportunity to brief the issue, to present oral arguments in court, and to expedite its consideration of the issue.

Major television networks covered the oral arguments that were presented on June 29, 1983 before the Louisiana Supreme Court. Attorney Bird argued that under both state and general law the legislature has the authority to prescribe courses of study and that they exercised that authority by passing the Balanced-Treatment Act. On October 17 the State Supreme Court ruled in favor of the act. The seven-member court was split four to three, and one dissenter stated that even though the legislature had the right to prescribe educational curricula, it could not foster the teaching or promotion of religion — and creation-science was a religious belief rather than a course of study.

The Supreme Court's decision prepared the way for a full trial in a federal court over the constitutional issues. Senator Bill Keith of Shreveport, sponsor of the Balanced-Treatment Act and founder of the Creation-Science Legal Defense Fund (CSLDF), announced that this trial would be "the major test [case] of all time" on the constitutionality of teaching creation-science in public school science classes.

While the deputized State attorneys filed a motion for partial summary, the ACLU filed a motion for summary judgment, which could be granted only where no facts are in dispute. On another front, the ACLU lobbied extensively for repeal, and although the State senate voted in favor of it, on June 25,1984 the House of Representatives voted 61 to 26 against repeal.

In September 1984 both sides filed massive briefs. The State brief contended that balanced treatment for creation-science was constitutional and that there were many material factual issues that prevented summary judgment without a full trial. It discussed the affirmative scientific evidence for biological, biochemical, and cosmic creation, the problems with evolution-science, and the constitutional issues (e.g., the Constitution did not require hostility towards theism). The ACLU brief stated that creation-science was fundamentalist religious doctrine in disguise which therefore violated the First Amendment. It further argued that academic freedom was violated when teachers were forced to present currently censored scientific information.

On January 11, 1985 Judge Duplantier entered a summary judgment ruling the Balanced-Treatment Act to be a violation of the establishment clause, because the concepts of creation and a creator are necessarily religious and therefore unscientific. In his ten-page written opinion, Duplantier stated that "the teaching of 'creation-science' and 'creationism,' as contemplated by the statute, entails teaching tailored to the principles of a particular religious sect or group of sects," and the statute "promotes the beliefs of some theistic sects to the detriment of others." He added that it was unnecessary to consider the evidence presented by the state.

Nature, a leading science journal, predicted that "because this time the decision came in the form of a summary judgment, finding that the law is unconstitutional, other states are unlikely to test the courts further." An ACLU spokesperson said that the decision "sets a precedent for a 'knock-out blow' to creationist statutes." Supporters of balanced-treatment appealed Duplantier's decision to the Fifth U.S. Circuit Court of Appeals, asking for a reversal because material factual issues exist for creation-science. The February newsletter from the CSLDF informed its supporters that the U.S. Court of Appeals for the Fifth Circuit had granted their motion to expedite the appeal, thus shortening the time required for appeal by at least half a year or perhaps even a full year. A verdict is expected soon.

Katherine Ching

LITERATURE REVIEWS

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

A VENTURE IN UNORTHODOXY

THE EXPANDING EARTH. 1976. S. Warren Carey. Amsterdam: Elsevier Scientific Publishing Co. 488 p.

Reviewed by Bill Mundy, Department of Physics and Computer Science, Pacific Union College, Angwin, California

This book is the tenth volume in a series on Developments in Geotectonics.

S. Warren Carey is an internationally known geologist at the University of Tasmania in Australia. His publications on tectonics go back to his Doctor of Science thesis entitled *Tectonic Evolution of New Guinea and Melanesia* done in 1938 at the University of Sydney. He has regularly published in this area since that time, being a proponent of Wegener's continental drift theory when it was generally being ridiculed. In 1953 Carey sent a paper to the American Geophysical Union proposing "the transport of continental blocks on the back of convection cells" with subduction of the crust at "the downgoing limb of the convection cell." The paper was rejected at the time "on the grounds that it was naive" (p 9). In 1971 Carey resubmitted this paper with an attached letter that included the following paragraph:

> *Although I worked with subduction models for more years than any of the new generation of subducers has yet done, I have since moved on to what I think are more probable models* (p 10).

And that is what this book is about, a "more probable model" which proposes "that the earth is expanding and that the separation of the continents by growth of new oceans is not extensively compensated by the swallowing of old crust elsewhere" (p 14). "That the diameter of the earth has increased with time at an increasing rate, is the theme of this book" (p 118). In fact Carey suggests that there is evidence that the surface area of the earth has doubled since the Paleozoic era (p 20, 47, 51).

The evidence that Carey cites necessitating an expanding earth are:

a) gaping gores, which appear to be false artifacts, in even the best Pangea assembled on a present size earth (p 39). "A coherent integral assembly is only possible on a globe of smaller radius ..." (p 27).

b) hierarchy of polygons into which the earth's crust is broken. Carey identifies nine first-order polygons (p 12) which are more or less equivalent to the plates of tectonic theory. He provides evidence that each of these are broken up into second order polygons which in turn, are broken into third order polygons, etc. (p 42). Carey suggests this is the natural consequence of the earth's crust accommodating to the increasing radius of the earth.

c) increase in area of each of the first-order polygons (tectonic plates) since the Paleozoic and an increase in the distance between the centers of each plate (p 47).

d) Pacific paradox associated with evidence that the Pacific Ocean doubled in size during the time that Pangea ruptured and dispersed and the Arctic, North Atlantic, South Atlantic and Indian Oceans developed (p 50).

e) consensus that Australia, South and North America, Africa, India and Europe have moved to more northerly latitudes since the Mesozoic era and yet are generally further from the Arctic now than then (p 52, 116, 199). In fact, as a result of the mid-Atlantic ridge, the Arctic Ocean is still expanding today.

f) young ocean floors. Carey feels that "it is incredible that no sizeable block of old ocean crust would be left anywhere" if the size of the earth has remained fixed but that this would be expected on an expanding earth (p 53).

g) close geologic association of India with Antarctica, Australia and Africa. On a globe of the earth's current radius it is not topologically possible to assemble Pangea so that India fits all these neighbors (p 435) but "*all* these close connections emerge automatically when Pangaea is assembled on a terrella of appropriate radius" (p 436).

Carey also discusses the double-equator paradox during the Triassic period (p 209) and the paradox of paleopole overshoot for the Tertiary period (p 215) as evidence for an expanding earth.

Carey reserves some of his most scathing comments about standard plate tectonics for the subduction trenches. He states, "Subduction exists only in the minds of its creators" (p 16) and "the Pacific subduction zones like all other subduction zones are myths" (p 50). This is the crucial difference between standard plate tectonic theory and Carey's expansion model, for both schools of thought agree on sea-floor spreading but differ on the interpretation of the trenches (p 54). Arguments that he uses to support these contentions are:

a) lack of off-scraping of trench deposits (p 56, 59-60).

b) thinning and necking of earth's crust in area of trenches and other topographic evidence that indicates the trenches are tensional rifts, not compressional features (p 28, 52, 59, 63-65).

c) increase in heat flux at trenches and orogenic belts which is not consistent with subduction (p 58, 69).

d) trenches do not correlate with rifts as would be expected on a fixed radius earth (p 57).

e) no indication from seismic data that the Moho bends down at the trenches (p 62).

f) magnetic anomalies get older away from the Aleutian trench as though it were a spreading zone (p 59).

g) paleomagnetic data fit expanding earth without trench subduction (p 183).

Carey cites studies which claim that seismic (p 74) and paleomagnetic data (p 195) have been screened and selectively interpreted to be consistent with assumed subductions.

In response to the question, "What causes the expansion of the earth?" Carey's first response is that he does not know. Suggested possibilities are:

a) phase changes in the earth core (p 124, 450).

b) secular decrease in the universal gravitational constant (p 451).

c) secular change in e/m (charge/mass of electron) (p 457).

The scenario that Carey proposes starts with a dense earth with an Archean crust broken by tensional rifts over a slowly expanding interior. Heat and gas escaped from the interior via the cracks with rocks changing to less dense phases along these boundaries causing these polygonal boundaries to arch upward to form basins for shallow seas. Due to "the inherent feedback instability of the outgassing process, some undations [formation of mountains by huge waves in the crust of the earth] inevitably developed more than others" (p 126). This process eventually led to the formation of the Pacific basin and Pangea. During the Carboniferous period asymmetric expansion developed a "mantle tumour" under the southern part of Pangea which led to the break-up and dispersion of Gondwanaland (Australia, Antarctica, Africa and South America) (p 134, 135). This large megatumor also resulted in a rotational asymmetry of the earth causing an axial wobble which the gravitational torques of the sun and moon turned into an axial tilt which led to the Permian glaciation. Viscous drag dissipated this tilt by the Jurassic period (p 135).

Carey argues that the obliquity of the rotation axis of the earth is the most important variable for geologic history (p 131). These changes affect the intensity of the magnetic field because changes in the paleomagnetic poles

govern climate changes and affect the motion of the plates. These cycles are related to the inability of heat interior to the earth to escape by conduction and stable convection, and cause instabilities to develop with the formation of megatumors which cause wobble and tilt. Also, excess heat is expelled by magma floods, crustal disruption and explosions (p 138).

Presumably another bulge during the Eocene epoch caused the present 23½° tilt of the earth and cause further dispersion of the continents (p 136). Greater expansion in the southern hemisphere tended to move the continents northward which increased the moment of inertia of the northern hemisphere tending to slow down the rotation of the north which created the "Tethyan shear" (p 271, 272). The fact that North America is west of South America is an evidence of this shear.

Carey suggests that two tests already demonstrate the validity of his model (p 443):

a) convergence of continents on an expanding Arctic.

b) convergence of continents on an expanding Pacific.

He proposes three more tests (p 443):

a) Check the earth to moon distance from three locations on earth, Canberra, Honolulu and Tokyo. Carey's model would show these places getting further apart whereas standard plate tectonics would suggest they are moving closer together.

b) Very long based interferometry using radio sources located in Alaska, California, Hawaii and Japan. Expect similar conclusions as above.

c) Direct measurement of the earth's diameter by time of flight measurements of neutrinos from Chicago to Cocos Island in the Indian Ocean.

Carey feels that these tests conducted over several years would be able to test his model.

Carey critiques the concept of uniformitarianism (p 114). He distinguishes methodological or immanent uniformitarianism (uniform application of natural law) and substantive or configurational uniformitarianism (uniformity in the environment). He feels that the principle of uniformitarianism is much too rigorously applied (p 114) and that we must allow for changes in even fundamental physical constants. He states, "We have no right to assume that unique events have not occurred, but must be alert to recognise them if they are recorded. Unfortunately we see only what we know, so the probability is, that if faced with the evidence of a unique event in the geological record, we would fail to observe it. As Claude Bernard said, 'It is what we think we know that prevents us from learning'" (p 118).

Much of the middle part of this book discusses technical details of paleomagnetism, rotational dynamics of the earth and solar system, and regional data.

Little reference exists in the literature about Carey's proposal of an expanding earth. There are a few geologists, in addition to Carey, who maintain an expanding earth hypothesis, including Krassilov, Owen, Shields and Stewart (Shields 1979). Among those who have criticized Carey's ideas, Cox claims that "paleomagnetic studies have now pretty well ruled out expansion large enough to account for the formation of all the ocean basins" (Cox 1973). Hess admits that an expanding earth removes some of the difficulties in dealing with the evolution of ocean basins, but he finds it philosophically unsatisfying. He does point out the difficulty of adding "an enormous amount of water to the sea in just the right amount...." Le Pichon notes that it would be necessary for the great circle of the equator and the great circles of longitude to expand at the same rate in order to maintain an approximately spherical earth. But "spreading rates" from axes of ridges would suggest that the equatorial circle is expanding more than twice as fast as the longitudinal circles on an expanding earth model (Le Pichon 1968). And with respect to the "subduction trenches" it is still not clear even with the conventional plate tectonic model whether the plates are being "pushed" or "pulled" down (Wyllie 1976). If the latter is the main mechanism, then these trenches would show tensional features even though subduction was occurring.

In conclusion, it does seem that Carey has raised some questions about plate tectonics and that his model does resolve some problems in the current theory. The three tests which he proposes are "do-able" and would provide essential evidence about the validity of the expanding earth hypothesis.

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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.

EVIDENCE OR PREFERENCE AS A FOUNDATION FOR BELIEF?

THE GREAT EVOLUTION MYSTERY. Gordon Rattray Taylor. 1983. NY: Harper & Row. 277 p.

Reviewed by R. H. Brown, Geoscience Research Institute

The Great Evolution Mystery is the last of fifteen books that distinguish Gordon Rattray Taylor as a brilliant writer and an original thinker. His broad scientific interests and his keen insight into issues of public concern, together with his literary skills, led to his selection as Chief Science Advisor for BBC television.

Throughout this book Mr. Taylor expressed unwavering implicit confidence in naturalistic evolution as the correct view concerning the origin and development of life. However, the book contains the best collection of scientific evidence for creation that I have seen! One might suspect that the author was a closet creationist who posed as an evolutionist to get evolutionists to hear the evidence against their viewpoint. But as far as I am able to discern, Mr. Taylor was fully honest in his approach. The vast array of contradictory evidence he has presented is directed only against the Darwinian and neo-Darwinian explanations for evolution. Having demolished Darwinism he offers no replacement, other than the confidence that naturalistic evolution is the only correct general view, and that a satisfactory scientific foundation for it will be found eventually. He suggests that this foundation may include modified elements of Lamarckism and an innate property of matter and organisms for self-direction toward higher complexity and greater adaptability.

I offer some quotations from *The Great Evolution Mystery* in hope that they will lead the reader of this review to a thorough reading of the entire book.

In a summary on p 137, the author refers to "at least a dozen areas where the theory of evolution by natural selection seems either inadequate, implausible or definitely wrong."

In reference to "the thirty or more reactions which are involved in making blood" the author says on p 183: "That these sequences of coordinated reactions — and there are literally thousands of them in the human body — should all have arisen by chance mutation of single genes is in the highest degree unlikely."

Concerning photosynthesis, he state on p 207, "Unless there was some inner necessity, some built-in, primordial disposition to consolidate into such a pattern, it is past belief that anything so intricate and idiosyncratic should appear."

On p 230 one read, "... perhaps the most serious weakness of Darwinism is the failure of paleontologists to find convincing phylogenies or sequences of organisms demonstrating major evolutionary change." Concerning the highly acclaimed horse evolutionary sequence, Taylor states, "The fact is that the line from *Eohippus* [*Hyracotherium*] to *Equus* is very erratic.... Specimens from different sources can be brought together in a convincing-looking sequence, but there is no evidence that they were actually ranged in this order in time."

On p 233 the author quotes L. von Bertalanffy to state: "'... the fact that a theory so vague, so insufficiently verifiable ... has become dogma can only be explained on sociological grounds.'"

The Great Evolution Mystery provides a strong basis for the conclusion that most people, evolutionists and creationists alike, adopt a theory of origins first, and then proceed to seek a scientific explanation for it.

GENERAL SCIENCE NOTES

ARE MILLIONS OF YEARS REQUIRED TO PRODUCE BIOGENIC SEDIMENTS IN THE DEEP OCEAN?

By Ariel A. Roth, Geoscience Research Institute

WHAT THIS ARTICLE IS ABOUT

How long would it take to produce the thick layers of microscopic shells found on the floor of the ocean? Would this not require millions of years, and would this not invalidate the scriptural account of creation a few thousand years ago?

For several reasons the argument for the necessity of a very long time required to accumulate the microscopic shells on the deep ocean floor is a poor one. At present some data indicate that there is a slow rate of production; on the other hand: 1) the layers of shells are not kilometers thick as has been reported, but probably at best an average of 0.2 km; 2) the biological potential of production is so great that this quantity of shells could probably be produced in much less than 2000 years; 3) a worldwide flood as described in Scripture could provide the nutrients necessary for such production; 4) caution is warranted because of the poor data that are currently available. Because of these factors a firm case against the biblical model of origins cannot be made on the basis of our present knowledge about these sediments.

Recently a number of individuals have raised the question about the conflict between the millions of years required for producing the thick layers of microscopic shells found on the floor of the ocean and the short time suggested in Scripture for life on earth. At first the question appears both reasonable and ominous for anyone believing in the truthfulness of the biblical Genesis account of beginnings a few thousand years ago. The layers on the ocean floor have been reported to be kilometers thick, and the shell remains comprising these layers are usually a small fraction of a millimeter in diameter. It could appear that millions of years are involved in their formation according to present average rates of production. On the other hand, when one considers the recent information regarding the small quantity of these sediments and the reproductive potential of the organisms producing the shells, the challenge appears at best to be equivocal. There are still a number of unresolved questions about this fascinating subject, and the last word is probably well in the future. Some findings and trends are quite significant to the question.

Over one hundred years ago John Murray, a meticulous scientist aboard the oceanographic vessel H.M.S. *Challenger*, pioneered the study of microscopic "shell"-secreting organisms in the open oceans. He also

studied the shell-like remains of these organisms on the deep ocean floor. A number of principles which he established have remained valid to this day. These organisms are important in the food chains of our major oceans, and the shells that are left by these organisms on the floor of the ocean can tell us something about the past history of our world. There is considerable interest in these tiny creatures, and the scientific literature discussing them is voluminous.

The oceans cover about 71% of the surface of the world. About 1/5 lie over the shallower continental margins; the rest cover the deeper ocean floor which is usually lined by finer sediment that includes the small shells mentioned above.

Estimates of the thickness of sediments on the ocean floor have varied considerably. Older figures postulate layers as thick as 22 km (Petterson 1954). Such thick layers were proposed in part to accommodate the large quantities of sediment expected from transport by rivers to the ocean over many millions of years. Around the middle of this century estimates were reduced to 2-3 km. More recently the use of seismic methods show that a major portion of the ocean floor has sedimentary layers less than 0.1 km thick, while a smaller fraction, mostly near the continental margins, has a thickness greater than 1 km (Berger 1974). An average depth of about 0.4 km may be generous for the floor of the oceans and is a few percent of what was conceived earlier.

It is usually assumed that the original oceans had no sediments and that directly or indirectly a major portion of the sediments now present were brought in by rivers. Therefore, with an earth over a billion years old, sediments from the rivers would have filled the oceans several times. The paucity of sediments on the floor of the ocean is now explained in part by the plate tectonics model which proposes that marine sediments are subducted deeper into the earth. However, this rate of subduction appears so slow compared to the present input to the ocean by rivers, etc., that the problem of where all the sediments go if one assumes a standard geologic time scale of billions of years is not solved. Estimates of the input of sediments into the ocean by rivers, coastal erosion, wind, etc., vary from 8 to 64 billion tons per year (see Holmes 1965, Holeman 1968, Milliman & Meade 1983), while the rate of removal of sediments by subduction has been estimated by Li (1972) to be at 2.5 billion tons per year. The present estimated volume of sediments on the ocean floor and margins (4×10^{17} tons) could be brought in by rivers, etc., at their present rate of transport in some 10 to 30 million years. One must postulate different conditions in the past to reconcile these figures to either a standard geologic time scale or a short period for earth history as described in Scripture.

Implicit in Scripture and in the folklore of many ethnic groups over the world is the account of a worldwide flood which, of course, represents conditions different from these presently observed which would cause rapid erosion and sedimentation.

The many different kinds of sediments on the floor of the deep ocean have varied sources. A little less than half of the ocean floor is covered by fine clay. Though sometimes called "red clay" because of its color, it is often not red. This clay usually originates from the continents or from submarine vulcanism. When more than 30% of the sediments consist of the shells of organisms, they are called oozes. About half of the deep ocean is covered by light-colored carbonate oozes, consisting mainly of calcium carbonate and containing an abundance of microscopic shells that are of special concern in this note. These shell-rich deposits produced by microscopic plants and animals living nearer the surface of the ocean cover about ¼ of our planet. When the organisms die, the shells sink to the ocean floor. A large 150 mm (0.15 mm) foraminiferal shell may take 10 days to sink to the bottom of the ocean; smaller ones take much longer. A significant number dissolve before they ever reach the ocean floor.

If all the water were removed from the ocean, one would be surprised to find the tops and flanks of the submarine mountains covered with whitish carbonate deposits including many microscopic shells, while the deepest parts of the ocean, usually 4500-5000 m below the present sea level, would be covered with darker clay sediments. This would give somewhat the same appearance as mountains on the continents covered with snow down to a given level sometimes called the snow line. In fact, the level in the ocean below which carbonate deposits are generally absent has sometimes been labeled the "snow line." More properly called the calcite compensation depth (CCD), it is that depth at which the rate of dissolution of calcium carbonate shells, etc., exceeds the rate of input from above.

A smaller portion of the ocean floor (about $^1/_7$) is covered by silicious oozes which are found mainly at high latitudes. These oozes are provided with an abundance of shells secreted by rapidly reproducing microscopic plants called diatoms and microscopic animals called radiolarians. Their shells which are composed mainly of silica (SiO_2) are in sharp chemical contrast to the more abundant carbonate (mainly $CaCO_3$) shells mentioned earlier.

The skeletal remains of many different kinds of organisms are found in the abundant carbonate deposits of the ocean floor. These are often called foraminiferal oozes because of the high proportion of foraminiferal tests (shells) (Figure 1a) present; however, these shells do not necessarily

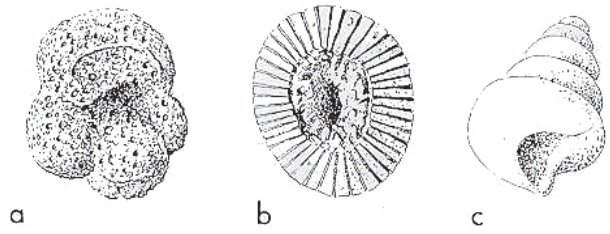

FIGURE 1. Examples of shells from organisms producing biogenic carbonates on the deep ocean floor. a) foraminiferal test (×120), b) coccolith (×400), c) pteropod shell (×30).

dominate the deposits. Three of the main types of organisms producing carbonate shells will be considered.

The foraminifera that produce these shells are called planktonic foraminifera because they live in the open seas. They produce a shell usually a fraction of a millimeter in diameter that often consists of several lobes or chambers (Figure 1a). A second group of major importance are plants called coccolithophores. These brown algae produce microscopic platelets often shaped like a small washer about $^{1}/_{100}$ mm in diameter called a coccolith (Figure 1b). One coccolithophore may secrete 12 to 100 coccoliths which form a sheath around the outside of the organism. A third group of lesser importance are the pteropods which are much larger (1-2 mm) snail-like mollusks (Figure 1c). While very interesting, pteropod oozes are estimated to cover less than 1% of the ocean floor and will not be considered here in detail.

Basic to the question of how long it would take to produce all these carbonate sediments are estimates of the quantities present. Major portions of the ocean-floor sediments have less than 1-2% carbonate (Kennett 1982, p 461). No exact figures can be given, but reasonable estimates can be suggested. Since shallow and deep ocean currents can transport these fossil shells for considerable distances and cause local accumulations of greater depth, average figures will have to be used. At present foraminiferal oozes dominate the ocean floor; however, this was apparently not the case in the past. Bramlette (1958) has shown that at least in the Pacific Ocean coccolith production was greater than that of foraminifera during the early- and mid-Tertiary. Another irregularity is that in the smaller Atlantic Ocean, sediments are usually thicker than those in the Pacific Ocean and have fewer “red clay” areas. One can estimate that for an average 0.4 km thickness of sediment in the deep ocean, about half (0.2 km) would be “red clay” and half (0.2 km) carbonate oozes. Of these about half (0.1 km) would be coccoliths and half (0.1 km) foraminiferal skeletons. We are not

dealing on an average with kilometers of foraminiferal sediments as has been conceived; nevertheless, considering how small these skeletal remains are, an average of 100 m of foraminiferal shells and 100 m of coccoliths can appear as a challenge to any model of rapid sedimentation.

Strange as it may seem, biological productivity does not appear to be a limiting factor. We are dealing with some of the fastest reproducing organisms known. In the surface layers of the ocean these carbonate-secreting organisms at optimum production rates could produce all the carbonate on the floor of the ocean in probably less than one or two thousand years. For instance, if one assumes a high concentration of foraminifera of 100 l^{-1} as has been reported (see Berger 1969), a doubling time of 3.65 days (Berger 1976, p 273, 299) and an average of 10,000 forams g^{-1} of carbonate (Berger 1976, p 298), the top 200 m of the ocean would produce 20 g carbonate $cm^{-2}y^{-1}$or (at an average sediment density of 2 g/cm^3) 100 m in 1000 years. Under present conditions all would not be preserved. As mentioned above, in the deepest parts of the ocean which are below the CCD there is dissolution of much of the carbonate. One might want to increase the time allowed, even by a factor of 2 to compensate for this, if one assumes that the CCD was at the same level in the past as now. On the other hand, increased carbonate input (as will be discussed later) would tend to lower the CCD (Berger 1976, p 308) and favor a greater proportion of preservation. Also, reproduction below the top 200 m would likewise tend to shorten the time required.

Although planktonic foraminifera have been the subject of extensive study, their natural life cycles are still poorly understood. Some factors suggest short life spans of a few days and great reproductive potential which favor rapid shell production. Bé et al. (1977) noted that one mother cell of *Globigerinoides sacculifer* collected near Bermuda released 280,000 gametes during gametogenesis which took about 13 hours. Spindler et al. (1978) reported comparable figures for *Hastigerina pelagica* and Bé et al. (1977) noted that in the laboratory shell chamber formation took place in a few hours.

Coccolithophores may reproduce faster than foraminifera and are "among the fastest growing plankton algae" (Paasche 1968), sometimes multiplying at the rate of 2.25 divisions per day. If one assumes that an average coccolith has a volume of 22×10^{-12} cm^3 (Honjo 1976), an average weight of 60×10^{-12} g per coccolith [Honjo's 1976 figure of 8×10^{-12} g is in error; he believes it is more like 80×10^{-12} g (personal communication)], 20 coccoliths per coccolithophore, 13×10^6 coccolithophores per liter as reported for Oslo Fjord (Black & Bukry 1979), a dividing rate of 2×/day and a density of 2 g per cm^3 for the sediments produced, one gets a

potential production rate of 54 cm of $CaCO_3$ per year from the top 100 m of the ocean. In other words it is possible to produce the average 100 m thickness of coccoliths proposed for the sea floor in less than 200 years. If one assumes that the CCD is at the same level now as in the past, the time should be doubled to allow for dissolution as mentioned for foraminiferal shells. One might also need to increase the time by some unknown factor to allow for light reduction due to the heavy concentration of these organisms that require light for coccolith production. Conversely one might need to reduce the time by some unknown factor to allow for those organisms producing coccoliths below the top 100 m of the ocean. Regardless, the biological potential for production is so great that it does not seem to challenge a model of a few thousand years for earth history.

It must be emphasized that the high rates given above are optimum and do not appear at all to represent average present-day rates. The figures given represent the biological potential of these organisms. There is a great deal of variation in the number of organisms present at different localities, and various methods of analyses yield highly differing results. Some recent studies using sediment traps (Honjo et al. 1982; oral reports, GSA annual meeting 1984) suggest that at present in a number of localities the carbonate flux to the floor of the ocean is in the order of 25 to 250 mg m^{-2} day^{-1} which is several thousand times slower than the potential figures given above. Such figures would appear to challenge Scripture; however, lack of precise information regarding the quantity of shells, much higher potential production rates and the nutritional enhancement of catastrophes must be given due consideration.

There is some agreement that the carbonate production rate by these organisms based on comparing the thicknesses of sediments in protected areas with the standard geologic time scale of millions of years is 5 to 10× greater than what appears to be the final average accumulation rates on the floor of the ocean (Berger 1970, Kennett 1982, p 459). This final accumulation rate is based on the amount of calcium carbonate and/or calcium ion supplied by the rivers to the ocean system. Rivers are the ultimate source of minerals for the oceans. It has been noted that rivers carry only about 10-20% of the carbonate that the organisms are estimated to produce now. The discrepancy between production by organisms and river input is explained by assuming that the major portion of the carbonate deposited on the floor of the ocean is dissolved and recycled into the system to form new shells. The discrepancy can likewise suggest non-equilibrium conditions, e.g., the rivers are carrying less calcium to the ocean now than in the past and equilibrium has not yet been reached. If one assumes a balanced steady-state model, it does appear that at present

the slow input of calcium carbonate into the oceans from rivers, etc., may be a major limiting factor in carbonate skeletal production and preservation in the ocean.

While evaluating whether the quantity of carbonate shells on the floor of the ocean challenge the validity of Scripture, one must take into account that any model must be tested using its complete conceptual framework and that implicit in the scriptural model is a worldwide flood which would produce dramatic changes in the sedimentary cycles of the earth. Of special significance would be a major input of calcium ion to the hydrosphere due to erosion of continental and marine environments. According to most models of the Genesis flood, the carbonate available would be essentially free of ^{14}C, thus giving old dates for the marine sediments produced soon after this catastrophe. The disequilibrium produced by such a catastrophe would be reflected in rapid continental erosion rates for many subsequent centuries as readjustments took place; also, carbonates that would have settled to the ocean floor could be dissolved and recycled through shell-secreting organisms, as is assumed to occur now to account for the greater production rate compared to river input mentioned above.

One would expect greater rates of production by foraminifera and coccolithophores after such a catastrophe due to the influx of nutrients from the destruction of the biota and the solution of minerals. At present, as expected, production is greater in regions of high nutritional concentrations (Berger 1969, Kennett 1982, p 462).

Under the right conditions significant increases in the concentration of marine microorganisms can occur as in plankton "blooms" and red tides. For instance, a microscopic bioluminescent protozoa in Oyster Bay, Jamaica is known to increase from 100,000 l^{-1} to 10,000,000 l^{-1} during bloom periods (Seliger et al. 1970). The reasons for these blooms are poorly understood but suggestions include turbulence of the sea, wind (Pingree et al. 1977), decaying fish (Wilson & Collier 1955), nutrients from fresh water inflows and upwelling, and temperature (Ballantine & Abbott 1957). Some of these conditions would be generated during a catastrophe such as a worldwide flood and could favor rapid production of carbonate skeletons by foraminifera and coccolithophores. The pollution from large duck ranches on the borders of Moriches Bay, New York is thought to contribute to a peak concentration of phytoplankton of more than 10 billion organisms per liter. On the other hand, if the Ca ion input was limited, the expected increase in CO_2 in the water resulting from decaying organic matter would favor the dissolution of carbonate shells reducing the rate of accumulation. The total picture appears much more complicated than the few comments this note will allow.

A few words of caution regarding our present state of knowledge are pertinent to this discussion. We have yet much to learn about the nature and origin of sediments on the floor of the ocean. The estimate given above of an average of 100 m of foraminiferal shells may be generous. Ph. H. Kuenen (1950, p 351) warns:

> *According to Arn. Heim, there is a general tendency to overestimate the percentage of tests [shells]. He contends that more than 90% of recent and fossil calcareous sediments consist of a fine calcium carbonate silt which has been formed by chemical precipitation. Although this estimate is probably much exaggerated there certainly is frequently a large measure of uncertainty as to the amount of lime represented by tests still recognizable and by lime in submicroscopic particles.*

Rates of production may be underestimated. With reference to pteropod shells in the north Pacific, Whitfield (1984) states that "the flux of calcium carbonate shells from the surface layers into the deep oceans has been grossly underestimated." Also because of poor sampling techniques, we do not appear even to have good figures on the abundance of these organisms. The usual procedure of collecting by using fine nets does not seem very adequate. Kennett (1982, p 543) feels that results obtained for foraminifera may be "much too low because many specimens are lost through coarse mesh sizes." Berger (1976, p 294) suggests that the large spread (10^8) of foraminiferal concentration reported in the literature may be largely due to different sampling techniques. He states "incredibly, concentrations are sometimes reported, and often quoted without specifying the mesh size used to filter the water; such numbers are essentially useless." He also refers to research results which warn that values for phytoplankton are "considerably higher" using a membrane filter instead of the usual net, yet membrane filters yield results that are "much smaller" than those obtained by settling techniques.

In conclusion, the thickness of the layers of microscopic shells found on the floor of the ocean is much less than proposed earlier. Present rates of production appear relatively slow, while the biological potential for the rapid production of these shells is tremendous. Limiting factors for rapid production such as paucity of carbonate sources and nutrients could be obviated by a worldwide catastrophe such as the flood described in Scripture. Information is meager and some of it of poor quality. Because of these factors the biblical model of origins does not seem to be invalidated on the basis of our present knowledge about the microscopic shells found on the floor of the ocean.

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EDITORIAL

THE MEXICO EARTHQUAKE — SOME AFTERTHOUGHTS

It happened suddenly, and the results were devastating. A major earthquake (Richter 8.1) shook Mexico City on September 19, 1985. The tremor which lasted about four minutes caused the collapse of over 250 buildings and the deaths of thousands. Ironically, many died in two large hospitals that had collapsed. Thirty-six hours later, a second tremor (Richter 7.5) caused further damage of upright and toppled buildings. The total number of badly damaged or destroyed buildings from the two quakes was estimated at 2500, and the number of deaths was expected to exceed 8000.

Such catastrophes surprise us. If we knew they were coming, we would be more prepared — or would we? In a way we know that they are coming; seismologists had warned about potential problems in Mexico City long ago, but Mexico City remained unprepared. Part of the reason for our surprise is that it is difficult to take the extraordinary very seriously when the ordinary is so dominant.

Usually life is relatively placid. The normal routine of daily activities is not exciting. Things do not change all that much. The geologist returning to his outcrop finds it very much the same as it was the day before. The laboratory scientist repeating his experiments over and over again to make sure they are valid is not attuned to the possibility of the unusual. Commonality can almost hypnotize us into thinking only of the ordinary. Then, once in a while, something unusual like an earthquake jars us out of our coma and makes us realize that life is not an even continuum, but is definitely episodic. However, we soon become retrapped into the dull, normal calm, and we are again unprepared for the shakeup of the unusual.

The dissimilarity between the normal and the unusual illustrates two contrasting modes of geological thought: *uniformitarianism*, which proposes that geologic changes occur by normal processes, and *catastrophism*, which proposes changes during unusual catastrophic events, often of worldwide proportions. Recent changes in geological thought about these concepts have made their definition imprecise; nevertheless, the general contrast between the two terms remains.

The Scottish geologist James Hutton (1726-1797) was primarily influential in promoting uniformitarianism (normal processes) to explain geologic changes. One of his more famous quotations illustrates his emphasis on slow, normal changes over long periods of time: “What more can we require? Nothing but time.” This mode of thinking is in sharp contrast to catastrophic explanations (unusual events) prevalent at that time. These explanations often included concepts of a worldwide flood as

described in Genesis. A little later (1830-1833) the English geologist Sir Charles Lyell published his *Principles of Geology* which has been called a polemic to destroy catastrophism and "to sink," as he worded it, "the diluvialists."

For more than a century, uniformitarianism was dogma in geological interpretation. It is only natural that this should occur, because one usually observes only slow, normal geologic changes, while catastrophic events are rare. Likewise in research, the replication which is highly desirable for the establishment of firm conclusions is much less accessible for the rare event; hence, investigation tends to concentrate on the readily available, normal data, and the matrix of results is biased in this direction. This in turn influences our concept of truth towards the normal which can be further reinforced by our intuition which tells us that the normal is reliable. The problem of bias due to the unavailability of information is not easily evaluated, and our concepts of truth are insidiously influenced by this. Hence, concepts such as uniformitarianism, which favor the normal, easily gain acceptance, even if they misrepresent the total picture.

Fortunately for geological thinking, the past two decades have witnessed a retrenchment away from strict uniformitarianism. A modified form of catastrophism has become acceptable. This is not a return to the classical catastrophism of events such as the Genesis flood but is a trend in that direction. The billions of years conceived for the development of the crust of the earth are still preserved by putting long periods of time between significant catastrophic events. The comments of several scientists in authoritative publications witness to the present trend.

> *It is a great philosophical breakthrough for geologists to accept catastrophe as a normal part of Earth history* (Erle Kauffman, quoted by Lewin 1983, in Science).
>
> *Of late there has been a serious rejuvenation of catastrophism in geological thought* (Brown 1974, in Geology).
>
> *The profound role of major storms throughout geologic history is becoming increasingly recognized* (Nummendal 1982, in Geotimes).
>
> *The hurricane, the flood or the tsunami may do more in an hour or a day than the ordinary processes of nature have achieved in a thousand years* (Ager 1981, p 54, in his book on stratigraphy).

The trend towards catastrophism has been generated by evidence found in the surface of the earth that witnesses to catastrophic activity in the past. It is a credit to geologists that among the dominant changes in geological thought that have occurred over the past quarter of a century, the unusual catastrophic event is gaining significant recognition.

Have we become sufficiently removed from the possibility of being trapped by the commonality of the normal? Obviously not, or the tragedy of Mexico City would not haunt us. Because of the plasticity of thought

induced by our frail memories and the ease of noting the normal, the normal will continue to bias our thinking. We tend to forget the unusual. Unique events such as worldwide floods conceived by classical catastrophism are even more difficult to envision and incorporate in our framework of reality, because such events are so remote — in time, magnitude, and complexity — from the normal that dominates our reference field. While such catastrophes may leave evidence of their occurrence, it is natural that we should have doubts about such unusual events; nevertheless, Mexico City reminds us that the exceptional may be very real. In our search for truth we must not fall into the trap of limiting our concepts to the normal; if we do, we may suddenly find that we are on shaky ground.

Ariel A. Roth

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REACTIONS

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

Re: Roth: The Disregard for Discards (ORIGINS 12:5-6)

I would just like to let you know that I am glad there are a *few* people left in the scientific society like you and your colleagues. I found the articles in Volume 12 #1 very interesting and well written. I especially enjoyed the editorial. If only more people could look at the whole picture without injecting their own bias against creation. Such is life on this planet, I suppose. Again, let me say that you should be congratulated on a well-done publication. Keep up the good work!

Kevan J. Evans
Vicksburg, Missouri

Re: Roth: The Disregard for Discards (ORIGINS 12:5-6)

Origins, Volume 12, Number 1, 1985 came in the mail yesterday, and I was intrigued by the editorial on "discards." Since you invited comments on articles in the journal, I will respond.

In the first place, *discard* is the wrong word. To discard a concept requires that unbiased judgment must be given to it by a group of competent authorities. In my opinion, it has not yet been demonstrated that evolutionists are any more qualified to judge the validity of theories regarding the origin of the earth and its life than are creationists.

Evolutionists have not, and cannot, discard creationism. They may have rejected it, but that does not mean that it has been thrown out onto the scrap heap.

As I have watched the battle during the last few years over the teaching of creationism in the public schools, I have noted that the reason why evolutionists oppose it is that they misunderstand what creationism really is. They claim it is religion, therefore it must be rejected by scientists — it has no place in science at all.

Now it must be admitted that belief in creation may be a part of religious dogma, under certain circumstances. A person who accepts it because he reads in Genesis 1:1 that "in the beginning God created" makes the creation concept a part of his religious belief. But there may be an entirely different approach to the problem of the origin of the earth and its life.

Although any kind of creationism must accept the postulate that there may be a Supreme Being, a Creator, accepting the data of what is known as "scientific creationism" does not mean that one acknowledges the Creator as his God and worships Him as such.

For thousands of years the Jewish community accepted the words of Genesis as true, which, of course, meant faith in the Creator. Then Christianity followed for another 1800 years without seriously challenging the creation concept. Since men — many of them intellectual giants — followed this line of thought for so long, we are forced to admit the *possibility* of a Creator. If evolutionists would banish such a possibility,

they would be virtually declaring that atheistic evolution is the only possible truth about origins. I wonder if they understand what such an assumption means. Do they really wish to promote a purely atheistic intellectual world?

Creationism — the concept of an earth produced by the act of an Almighty God — may be accepted as scientific on the evidence from nature itself, for there are many aspects of the world and its life that purely random physical and chemical processes can never explain. While we must admit that evolutionists have much evidence on their side of the case, we still maintain that there are strong evidences for scientific creationism. To admit such a possibility does not involve religious faith.

Care must be taken at this point to correctly define religion. Simply recognizing the possibility of a Creator is not religion. The dictionary defines religion as acceptance of God as the Supreme Ruler of the universe, and giving to Him our allegiance and worship.

Another reason why many reject creationism is ignorance. They are blind, either willfully or unwittingly, to the evidence that is being brought out by careful investigation of nature, showing that many aspects of nature cannot be explained as due to pure chance, natural selection, or any other automatic processes.

Take, for instance, the evidence for design. In the late 18th century William Paley, an English clergyman, basing his *Natural Theology* largely on the work of John Ray's *The Wisdom of God Manifested in the Works of Creationism* (1691), enjoyed great popularity until Darwin's work established the current views regarding evolution.

While Paley's work may have had some faults, due to the inadequacy of scientific knowledge in his day, many facts of modern science indicate that his philosophical views were along right lines.

We might cite one or two such lines of evidence; many could be given. Take, for example, the development of the bird's egg.

The bird has only a left ovary. At intervals yolks are released from this, each with a nucleus. Sperm traveling up the oviduct fertilizes the egg nucleus. As the fertilized egg begins its travel down the oviduct, layers of albumen are laid around it, forming the "white"; then, passing through the shell gland, it receives a coating of limy matter, forming the shell. Finally, another gland lays on the color pattern that is characteristic for the particular species.

Now I would challenge any scientist to show how natural selection could possibly develop all this elaborate mechanism.

The last few months we have been viewing on TV some of the marvelous creatures of the earth. I was especially interested in the case of a certain tropical flower which provides a slippery slide leading down into a pool of sweetened water. An insect attempting to reach the sweet liquid slips down into the pool. The only way out is through a hole on one side just above the surface of the water. As he crowds through this hole, a little arm just above him clamps down and holds him fast, while another arm covers his head and back with pollen. Then he is released. As he alights and tries to dry out, others of his kind crowd around, attracted by his sweet covering. They are dusted with the pollen on his head and back, and, as they seek other flowers, carry this pollen to them.

Will anyone please explain how natural selection could ever develop such an elaborate mechanism?

These are only two illustrations among many that might be given, for which there is no other explanation than "design" — intelligent planning.

Creationism has not been discarded. If the scientific world would sit up and take notice, it would find almost endless examples that compel one to believe in a Creator who has planned complicated structures that no amount of random variation could possibly produce.

Harold W. Clark
Calistoga, California

Re: Ray: An Evaluation of the Numerical Variants of the Chronogenealogies of Genesis 5 and 11 (ORIGINS 12:26-37).

The data P. J. Ray presents do not support his contention that the LXX manuscripts exhibit "various forms of schematization" because of numerical variants in the Genesis chronogenealogies. Some variants are mere slips in transcription; the rest of his "variants" do not exist at all and are the result of missreading the critical apparatus. Just to take the first verse he quotes in his table (Gen 5:3), the variants "130" and "330" are credited to the LXX, but "130" is not a LXX variant, just the MT one. The siglum oi l' which he cites means oi loipoi', "the remaining" (sc. Greek versions), i.e., precisely not the LXX, and appears as an ancient marginal note in the Hexaplarian Syriac version, to alert the reader to the fact that the LXX differs at this point from other forms of the OT. That version is recorded as "Syh." The same ancient note appears in a manuscript of the tenth century (424), but this also carries the reading "230" and not, as Ray states, "130." The remaining witness to which he appeals (135), from the same century, reads also 230 but adds in a footnote the words "the Hebrew reads 130", which is the equivalent of the previous note. In summary, there is no LXX manuscript whatsoever for the reading "130." Similar mistakes are repeated throughout Ray's tables. As for the reading "330" in two manuscripts (424 and 31, to which 59 should have been added), it does not represent any novel "form of schematization" because the same manuscripts read "700" as the number of years of Adam after begetting Seth (Gen 5:4) and then give the age of Adam at death as "930" (Gen 5:5). No schematizer would maintain that 330 + 700 = 930, no matter how odd his scheme could be. All such variants are therefore unintentional.

In any case I am at a complete loss to see how the corruption of a text by late handwritten copies reflects bad on the value of the earlier text that we possess. For instance, in the case of the verse studied above, all the manuscripts that read "330" date from the XV century (i.e. are contemporary with the printing press). Now, if the reading "330" makes the reading "230" less reliable (even though such is the unanimous reading of all the remaining manuscripts, including several uncials dating back from the IV century) then we could turn any portion of the Scriptures we don't like into something "unreliable" just by making altered copies of the Bible. In the old copies of the LXX, however, the chronogenealogies are anything but "inconsistent" as Ray wants. Whatever the value of the LXX figures (and this is still an open question) it cannot be ascertained by an examination of the critical apparatus. Dr. Hasel's arguments, though still debatable, were much more cogent.

Aecio E. Cairus
Berrien Springs, Michigan

Ray replies:

I appreciate A. Cairus' concern that in some cases my data do not represent variants of the LXX. It will be noticed (cf. Sigla) that I included among the data a wide variety of texts (some including the Bo and Sa which are daughter translations of the LXX) as part of the overall evidence, since these are also included in the critical apparatus of the LXX. It would have been clearer on my part to have labeled my tables as "Variants of the LXX and the Versions" and "LXX Manuscripts and the Versions". This, however, was an organizational problem rather than one of accuracy. That the Hexaplaric evidence should not be included as part of the LXX variations is a matter of debate. Since the Syh is believed to be the rendering of Origens' fifth column of the Hexapla, which constitutes his recension (edition of an ancient text involving a revision of an earlier text) of the LXX in Syriac, both it, where extant, and the MSS which follow it or its Greek original, should be included in the overall evidence of the LXX. Therefore I maintain, contrary to Cairus, that there is, indeed, evidence for a variant "130".

Anyone who has worked at all with the critical apparatus of the LXX is aware of its complexities and that it is relatively easy to make mistakes. These, to the best of my present knowledge, have been corrected and are included in the World Wide Web version. Cairus is not without his own scribal error (cf. MS 424 for MS 344 in the Hexaplaric apparatus) and misreading of the critical apparatus (MS 59 should remain with variant "230").

In addition to the above, the main thrust of my study was not schematization. This was Dr. Hasel's argument. I only added a few further observations to this based on my own study. My main point, though I may not have laid enough emphasis on it, was that the LXX data (including the versions which reflect this to a certain extent in those that apply) is more complicated than just the evidence from the Codex Alexandrinus and those many MSS which follow it.

Now if I understand Cairus correctly, he assumes that older is better, that MSS are counted rather than weighed, and that variants are equivalent to errors (cf. his paragraph 1, second sentence and paragraph 2). Indeed, many times the oldest extant MS does reflect an original reading, and the evidence from a large number of MSS with the same reading *may* also point in that direction. However, this is not always the case, as I pointed out in my study, unfortunately without examples. I hope to remedy that here. Other areas of the Biblical text besides Genesis 5 and 11 have differences in the numerical data between the MT and LXX. A prime example is 1 Kings 6:1, where the MT reads "480", whereas the LXX (MSS ABMN d-hjm-qstv-a_2) read "440". However, LXX (MSS Zbi$c_2$$e_2$) read "480" as with the MT. The earliest, as well as the majority of the LXX MSS, support the reading "440". Should this then be the preferred reading? The latest views on the history of the Biblical text in relation to the LXX suggest that for the books of Samuel - Kings, MSS bo$c_2$$e_2$ (19 + 108 82 127 93 Göttingen) all 11th-15th century A.D. MSS actually reflect a proto-Lucianic recension (revision of the LXX) in about the second or first century B.C. (cf. Cross, F. M. 1966. The Contribution of the Qumran Discoveries to the Study of the Biblical Text. Israel Exploration Journal 16:84). Therefore, b$c_2$$e_2$, though late MSS, are seen to reflect an earlier form of the LXX than the earliest extant MSS (AB et al.). The preferred reading here on this basis should be "480", which also agrees with the MT. An appeal to those proto-Lucianic MSS should not always be seen as an easy solution; however, in that as can be observed, the

evidence is often divided (cf. MS o = 82 reads "440") and sometimes conflicts with known historical data (cf. Thiele's response to Shenkel in Thiele, E. R. 1974. Co-regencies and Overlapping Reigns among the Hebrew Kings. Journal of Biblical Literature 93:174-200).

Applying this to the Pentateuch, and more specifically Genesis, the proto-Lucianic MSS are gn, dpt (54, 75, 44 106 134 Göttingen cf. Cross 1966, p. 84). These again are 11th-15th century A.D. MSS. To take but one example, in chapter 11 verses 17 and 18, the d group (including both MSS 44 and 106), as well as MS 54, support readings other than that of MS A and the majority of the MSS (cf. Table 4). These *might* indicate earlier readings, although one must be careful since the remaining proto-Lucianic MSS support other readings for these same verses. Nevertheless, this type of evidence should be taken into account as being possibly earlier than the majority reading, which follows Codex A, even though coming from late MSS. This does not make the majority reading "unreliable," "less reliable," or of "lesser value." I only meant to suggest that the evidence is more complicated than has thus far been dealt with in previous studies of the differences between the texts in these two chapters. In addition, schematization *may* also be a factor in the example cited, as well as in similar situations where variants based on these MSS exist. Thus, although scribal error may play a role in the overall variants in these two chapters, it can by no means account for all the variations as previously pointed out (cf. p. 35).

As to the question of whether or not the LXX was subjected to more "corruption" than the MT, the answer would seem to be a *qualified* yes. Hebrew MSS, of all three text-types (MT Sam. LXX), have shown up at Qumran (i.e., The Dead Sea Scrolls). The textual history is more complicated than this, but the MT grew out of a crisis faced in Judaism after the destruction of Jerusalem in the late first century A.D. One of the several Hebrew text-traditions then in existence was chosen as authoritative and the rest were systematically repressed (alluded to in footnote 2). Thus, the MT MSS of medieval times are relatively consistent (cf. Goshen-Gottstein, M. 1967. Hebrew Biblical Manuscripts: Their History and Their Place in the HUBP Edition. Biblica 48:243-290), as opposed to the LXX which was allowed to develop in various directions (Christian ones at that, since the LXX was renounced by Greek speaking Jews and replaced in their community by the Greek versions of Aquila, Symmachus and Theodotion) to a limited extent. Since we are aware of the different Hebrew text-traditions of the pre-Christian era at Qumran, from the MSS and fragments which carry them, it must be concluded that the Hebrew scriptures did *not* exist in only one authoritative form before ca. A.D. 100. Rather, the ancient Jews, unlike us moderns, were content to live with a multiplicity of forms (though these were *not drastically* different). Therefore, the pre-A.D. 100 Hebrew text history is analogous to that of the LXX before Origen's Hexapla, and also the textual history leading up to the Samaritan recension. This may be traced to some degree where we have evidence from Qumran and related sources. So far, there is none for our two chapters. Thus, my conclusion that the MT would seem to preserve the figures closest to the original because the numerical data is consistent in all of the known MSS is an argument from silence and may be somewhat overstated. However, due to the repression, and thus absence, of contemporary conflicting text-traditions and at Qumran, the accidents of preservation, as well as the fact that we will never have all of the evidence, this is perhaps, after all, a fair estimate of the present situation.

Re: Ray: An Evaluation of the Numerical Variants of the Chronogenealogies of Genesis 5 and 11 (ORIGINS 12:26-37).

Correct and reasonably complete data are of paramount importance for the outcome in any type of research. I therefore limit my remarks mainly, but not exhaustively, to the aspect of primary data.

Using Wevers' Genesis edition of the Septuagint, Ray intends to "list all of the Septuagint manuscripts where these numerical data may be found." In reality Ray uses only about 70% of the manuscript data accessible from Wevers' edition. This means that if completeness is intended, Ray's enumeration is short of approximately 1100 data. Furthermore, the listings follow no perceivable organization and contain the inordinate amount of about 200 errors and shortcomings of various kinds. Even the sigla section has its share of wrong or confusing information. The bibliographical misspellings are embarrassing.

It is futile to merely list manuscript sigla without conveying to the reader their significance and implications. Appropriate characterization and categorization correlated with contextual linguistic features must be present. Without such an analysis, based on reliable data, discussions and conclusions are guesswork.

Variants from other ancient versions should not automatically be made part of the Septuagint complex. They need to be more complete and include intra- and inter-versional considerations prior to their being associated with it.

Quotations from, or reference to, these lists constitute a hazard. The work has to be started all over again, preferably not only with a rudimentary variant recognition ability, but with sufficient mastery of the methodology of textual criticism to avoid the pitfalls encountered here.

Johann E. Erbes

Ray replies:

I would like to thank Dr. Erbes for pointing out some problems with my study. As for the completeness of the data, I have listed the LXX MSS (and MS groups) which appear in the critical apparatus of Wevers. If Erbes' statistics are correct, this constitutes about 70% of the accessible data and reflects a representative amount of MSS The other "30%" may be deducted by a comparison of those MSS and MS groups listed in the apparatus with those given in the MS line (i.e., the MSS and MS groups consulted in reconstructing the particular section of the text appearing on any given page). Thus, my tables reflect only the MSS cited in the apparatus, but not those which could have been deducted. This type of deduction was, to my recollection, only done in footnote 1. It was not done elsewhere in order to keep the table section of the paper at a reasonable length. This, however, was unfortunately not conveyed to the reader.

In regards to the "200 errors and shortcomings" (about 7.8% of the "70%"), if this is the case, then I agree that quotations and references should not be made to these tables as complete and correct. However, this study, along with additional observations made in the letter to Cairus, might still be used as a starting point for future work in this area. It is representative of the fact that the data of the LXX is much wider in scope than a simple comparison of the Codex Alexandrinus with the MT and the Samaritan

Pentateuch would indicate for these two chapters which, to my knowledge, is all that has previously been done.

Indeed, the type of study proposed by Erbes is much wider than the scope which I had intended, notwithstanding the organizational problems. It would involve, to start with, a similar but broader study of the LXX in these two chapters, and at least all of the daughter versions (a rather difficult undertaking at a time when many of these versions as yet do not have critical editions of their own). All these data would then need to be categorized and compared text-critically before making a thorough evaluation. Though this type of study has not been undertaken here, it nevertheless has pointed to a need to take into account the more extensive nature of the LXX data available for comparative studies in these two chapters.

ARTICLES

CAN SCIENCE AND RELIGION WORK TOGETHER?

Leonard R. Brand
Professor of Biology
Loma Linda University

WHAT THIS ARTICLE IS ABOUT

The most important characteristics of a good scientific theory or hypothesis are that it can be experimentally tested and stimulates scientific progress by suggesting useful experiments to be done. Both creation and evolution contain testable as well as untestable hypotheses. Hypotheses about ultimate causes, or whether God has or has not involved himself in earth history cannot be tested by any experiment. However, hypotheses about the existence of fossil evolutionary intermediates or about the sedimentary environment in which fossil-bearing rocks were deposited can be tested. In other words whether or not a supernatural event (divinely initiated creation or worldwide flood) occurred is not scientifically testable, but if such an event occurred, it would likely have left behind physical evidence. Hypotheses about this physical evidence can be devised and tested.

In attempting to study geologic history, one important limitation affects both flood geologists and conventional geologists alike. The interpretation of geologic history is accomplished mainly by comparison of geologic deposits with modern analogues — modern processes of erosion and deposition. Since the rapid, large-scale geologic processes that would occur in a worldwide flood cannot be observed today, this introduces a heavy bias against the recognition of evidence for a geologic mega-catastrophe.

The finding of evidence to confirm the reality of a global geologic catastrophe would not prove that God caused a flood, but it would indicate that it is not unreasonable to believe the flood story if our confidence in Scripture leads us to do so.

The study of earth history involves research on the nature of events that we have not observed. Because of the uncertainties that this introduces, acceptance of any theory of origins involves a definite element of faith.

A method of dealing with conflicts between Scripture and current scientific interpretations is proposed. In this method, both science and Scripture are taken seriously. New scientific theories challenge us to more careful study of the Bible, to determine if it really says what we thought it says, or if we are reading something between the lines. We then decide if there really is no conflict between the two, or if the Bible is indeed saying that something is wrong with our data interpretation, and more research is needed.

To many people the term "Scientific Creationism" seems to be a contradiction. How can creation, which by definition involves supernatural phenomena, be scientific? This seeming contradiction disappears if we approach the study of origins with an adequate understanding of how science operates; what science can do and what it cannot do.

Let us begin by defining the role of a theory in science. A good scientific theory or hypothesis will have the following characteristics:

1. It explains and organizes previously unrelated facts.
2. It suggests useful experiments to be done, thus stimulating scientific progress.
3. It is testable — experiments can be performed that have the potential to support it if it is true, or to falsify (or disprove) it if it is wrong. These experiments must be repeatable, which means that other scientists should be able to do the same experiments and get the same results.
4. It predicts the outcome of untried experiments. If a theory can predict the outcome of an experiment, our confidence in the theory will be increased.

Does a good scientific theory have to be true? We certainly hope it is true, and a scientist would not waste time on a theory that he thought to be false. But the truth of the theory is what we are trying to determine with our experiments, and we do not know for sure which of our theories will continue to be supported and which ones will turn out to be false. The history of science has shown many times that a false theory can have the characteristics of a good theory and can effectively guide scientific advance for a long time (even hundreds of years) before the accumulating evidence leads some creative individuals to decide that a new theory is needed (Kuhn 1957, 1970). Theories are tools to organize our thinking and to direct our research in a profitable direction. They are valuable practical tools, but that does not necessarily mean that they are absolute truth. They may be only stepping stones in our search for truth.

WHERE DOES A THEORY COME FROM?

It is often implied that because creation originates from religion, it is *therefore* unscientific. Does the source of a theory affect its validity? Philosophers of science have struggled with this question and have concluded that we objectively define the source of a scientific idea (Popper 1959). If a scientist watches a witch-doctor at work (a very unscientific source of ideas) and develops the theory that some of the "doctor's" herbs have medicinal value, is that an unscientific theory? Not if it can be experimentally tested.

A theory is not scientific or unscientific because of its origin; it is scientifically useful if it can be tested; and if it cannot be tested, it is outside the realm of science (even though it may be true).

TESTABLE AND UNTESTABLE THEORIES

Some would conclude that the above definition has already eliminated creation from the realm of science, but perhaps it is not that simple. We can define certain testable aspects and other, untestable, features of both creation and evolution.

Nontestable Hypotheses	Testable Hypotheses
♦ God created life.	♦ All living and fossil organisms fall into discrete groups, without series of evolutionary intermediates between major groups.
♦ God did not create life.	♦ Series of intermediate forms between major groups of organisms have existed in the past.
♦ Vertebrates originated by evolution from the echinoderms. ♦ Echinoderms and vertebrates were both created by God.	♦ The simplest vertebrate animals have more anatomical, physiological, and embryological similarities to some echinoderms than to any other group of invertebrates.
♦ God caused a worldwide flood.	♦ Much of the geologic column was formed quite rapidly and catastrophically
♦ God did not cause a worldwide flood.	♦ The geologic column has formed very slowly over hundreds of millions of years. ♦ The Navajo Sandstone was deposited under water. ♦ The Navajo Sandstone was deposited in a desert.

I propose that scientifically useful (testable) theories like some of those listed above can originate from religious concepts. We cannot directly test whether God involved Himself in earth history, but if He did involve Himself in ways described in the Bible (creation and worldwide flood), those events should have left some evidence in the natural world (no evolutionary intermediates; evidence for catastrophic geologic action). The possible existence of such evidence can be investigated scientifically.

CAN FLOOD GEOLOGY THEORIES BE TESTED?

Many creationists and evolutionists would agree that the question "Did God cause a worldwide flood?" cannot be answered by science, but their reasons for believing so could be quite different. It is impossible to devise an experiment to test whether God caused a flood, but in addition to that, most scientists make the *a priori* assumption that there has never been any supernatural intervention in earth history. In fact, that assumption has been built into the very definition of science for nearly a century. Presently, to believe in supernatural events is to be, *by definition*, unscientific. However, that assumption is really just an untested hypothesis, not a fact that has been demonstrated, or even can be demonstrated by scientific data. Not only can science never prove God *has* influenced our geologic history, but it is equally impossible for science to prove that He *has not* influenced our geologic history.

These are philosophical questions of ultimate causation that we cannot test by any conceivable experiment. Rather than denying that our universe could ever have been influenced by any Being more powerful and intelligent than ourselves, it would seem a bit more open-minded to simply recognize that if there have been supernatural events, science could not study them unless those events have left sufficient detectable evidence to allow us to test hypotheses about the physical results of the supernatural event.

For example, the approach of the flood geologist is to propose that at some time in the past there was a disturbance in the earth's crust that temporarily disrupted the normal relationships between land and water bodies, initiating a period of rapid geologic activity on a worldwide scale, and this period of rapid erosion and sedimentation produced a significant portion of the geologic column. According to this hypothesis, the geologic and geophysical processes occurring during that event produced the characteristics of the rock formations formed at that time, including the distribution of fossils and the arrangement of the levels of radioactivity in those minerals used in radiometric dating.

Where this theory came from is beside the point. A flood theory expressed in this form is a simple descriptive statement and says nothing about the untestable question of whether God was involved in initiating this geologic event. It does not attempt to explain any process or event that may have operated outside the *known* laws of chemistry or physics. This descriptive theory can be used as a basis for defining specific hypotheses concerning the sedimentary processes and the amount of time involved in depositing individual formations, or the processes that produced various other geologic features. These hypotheses can be tested in the same way that any geologist tests his hypotheses.

Two geologists could be doing research on the same rock formation, perhaps one of the Paleozoic formations in the Grand Canyon. One geologist believes that the formation (like other geologic formations) must have had a long time — thousands or millions of years — in which to be deposited. The other geologist believes that the formation must have been deposited far more quickly than that. They both look for the same general type of data as they study the rocks. Each one must analyze the data that he finds, as well as other published data, and interpret their meaning. When they disagree, each geologist will analyze the other's work, and his own work, and try to determine what additional data are needed to clarify the issue. If each is doing good work, he will then publish his findings in a scientific journal so that other scientists will benefit from his work. In time, as more data accumulate, it is hoped that the conflicts will be resolved, and the total body of data will clearly favor one explanation — it will point to either rapid deposition or very slow deposition of the formation.

Both flood geologists and other geologists believe that if we are completely fair with the data, *eventually* the data will tell us which theory is true (*unless* we are not able to collect the types of data that can provide such information, without being able to go back in time and directly observe what happened in the past). Both types of geologists will also use the same observational and experimental procedures in their research. There is only one real difference in the research approach of flood geologists and other geologists: the flood geologist believes that when the data are all in, or at least a significant portion of the data, they will indicate that much of the geologic column was deposited in a short time. A conventional geologist approaches his research with the conscious or unconscious belief that when the data are all in, or mostly in, the data will indicate that all of the geologic column was deposited very slowly, or in rapid spurts with long periods of time in between. The flood geologist notes with interest the definite trend toward catastrophism that is evident in geology in recent years, but judging from the history of other fields of science, it could take many decades, or hundreds of years, before there are adequate data to fully resolve the issue.

Many would say that the data are already conclusive and have already disproved the flood theory. Why have the data not demonstrated the reality of the flood? Discrepancies between a theory and the available data can arise in at least two different ways — either the theory is wrong, or there is an important discovery waiting for the diligent researcher who uses the theory to guide his research. Creationists and flood geologists recognize that if their theory is true, there must be some significant phenomena yet to be discovered. Does creation stifle research, as some have suggested? Some approaches to creation may stifle research, but if it is understood correctly and if its predictions of new phenomena waiting to be discovered are taken seriously, it could be a stimulus for vigorous new approaches to research. The scientist who uses the Bible as a source of ideas for developing hypotheses should be able to operate as a successful researcher and, I believe, should even have an advantage in generating successful hypotheses.

LIMITATIONS IN STUDYING THE PAST

As we attempt to study the history of the earth and of life on earth, one limitation of the scientific method must be clearly understood. Interpretation of geologic history is accomplished primarily by comparison of rock formations with modern analogues. If a geologist is studying a sandstone layer, he would like to know under what conditions it was deposited. He cannot go back in a time-machine to observe its origin, so he will find modern processes (rivers, wind, ocean waves, etc.) that produce sand deposits, and compare these modern analogues with the sandstone formation. He will try to determine which modern analogue produces a deposit with characteristics most similar to the ancient

sandstone. If the sandstone matches most closely the deposits formed by underwater sand dune fields that are sometimes found offshore in shallow ocean water, it will be concluded that the ancient sandstone was also produced by a similar offshore dune field. It is like taking a multiple choice quiz:

This sandstone deposit was formed under which of the following circumstances:

A. River deposit
B. Desert sand dunes
C. Beach sand deposit
D. Marine offshore dunes
E. Turbidity currents

If the sandstone was indeed formed by one of the processes A-E, the research method described above should be an effective way to find the answer to our question. But what if the sandstone was not deposited by any of the processes A-E? What if it was deposited in an environment not observable on the earth today? What if it was deposited by a rapid, large-scale flow of water during a global geologic catastrophe? Such a deposit would likely be quite similar in many respects to sand deposits in one or more of our modern analogues.

Our real choices would then be A through E as listed above plus:

F. Rapid underwater sand deposit during a worldwide flood.

Of course, the problem is that alternative F does not have any modern analogue that we can study; so most geologists would choose one of the modern analogues as the correct answer. In doing so they would have reached a wrong choice, and the logic of our research approach would have become, as Charles F. Kettering has stated, "an organized way of going wrong with confidence." A geologist who believes in a worldwide flood did not observe that flood, and he also has access only to modern analogues of A-E. However, the flood geologist will at least be more aware of the possibility that our modern analogues may not be adequate to explain all of the geologic data. "Inasmuch as geologists are forced to interpret ancient sediments chiefly by analogies with modern phenomena, interpretations are severely biased if all possible analogues are not known..." (Stanley et al. 1971). Since no one has witnessed geologic activity on a scale even approaching that expected in a worldwide flood, there will naturally be a heavy bias in favor of geologic processes and rates that are within the range of what man has witnessed. Some data may force a recognition of greater forces and rates, but only a scientist who takes seriously the Noachian flood account is likely to be adequately prepared to recognize evidence for rapid, worldwide geologic activity on a grand scale.

Now, let us change direction and look at the other side of the coin. Even if the flood geologist uses his theory effectively and makes discoveries that

others have overlooked, there will be limits on the scientific conclusions that he can draw from his data. Science cannot demonstrate whether God was or was not involved in influencing our geologic history. Even if research eventually demonstrates that the best explanation for the geologic column is rapid sedimentation of most of the column in one short spurt of geologic activity, that would not prove that God caused a flood. But it would demonstrate that it is reasonable to believe the flood story if our confidence in Scripture leads us to do so. God never promised us proof; He only promised us reasonable evidence on which to base our faith.

This principle can be further illustrated by consideration of a specific formation — the Navajo Sandstone — and by trying to decide what kind of evidence would tell us if it was a flood deposit. It is often helpful to begin by trying to think of all possible models, or theories, that could perhaps explain a particular phenomenon. Here are several possible models for the Navajo Sandstone:

Wind 1. Deposited by wind over hundreds or thousands of years in a normal desert environment.

Wind 2. Deposited rapidly by wind during a period of unusually persistent high winds, but otherwise not in a catastrophic setting.

Wind 3. Much of the geologic column was deposited rapidly and catastrophically, and the Navajo Sandstone was one formation that was deposited rapidly by wind. However, God was not necessarily involved, and this rapid deposition had nothing to do with Noah's flood.

Wind 4. Deposited very rapidly by wind, during the latter part of the Noachian flood, during a period of lowered water level and persistent high winds.

Water 1. Deposited over hundreds or thousands of years by water, as the water slowly or periodically carried sand into the area.

Water 2. Deposited rapidly in an area with persistent relatively rapid water currents and a plentiful sand supply. Otherwise not in a geologic setting that was especially catastrophic.

Water 3. Much of the geologic column was deposited rapidly and catastrophically and the Navajo Sandstone was one formation that was deposited rapidly by water. However, God was not necessarily involved, and this rapid deposition has nothing to do with Noah's flood.

Water 4. Deposited rapidly underwater, by the persistent water currents during the Noachian flood. The sand-sized particles were not necessarily produced during the flood, but came

from extensive beds of sand that were part of the preflood world, and were transported into their new location during the flood.

A flood geologist may predict that the correct model is either Wind #4 or Water #4, and Water #4 may seem more likely than Wind #4. (However, we cannot rule out Wind #4 without adequate evidence, since we don't know what was all going on during the flood). When we consider the evidence for model Water #4, it is important to be very careful not to get ourselves into trouble. If we can produce compelling evidence that the Navajo Sandstone was deposited underwater, is that evidence for the flood? Not really, because that evidence could also be explained equally well by models Water #2, 3 or 4. Evidence that can be explained by two or more models cannot properly be used as evidence for any one of these models. If it fits two models equally well, it cannot tell us which model is more likely correct. We need evidence that fits one model and contradicts the other model.

Now, what if we find evidence that indicates that the Navajo was deposited underwater and was deposited *very rapidly*? What does that tell us? That evidence would eliminate models Wind #1-4 and Water #1, but it would still be consistent with models Water #2-4. We still have not shown that it was part of Noah's flood. If we then find convincing evidence that much of the rest of the geologic column was also deposited catastrophically, we have eliminated all except models Water #3 and 4. What scientific evidence would tell us which of these two models is correct? Science can never demonstrate that God *was* or *was not* involved in influencing earth history. The choice between models Water #3 and 4 or between models Wind #3 and 4 will always involve a strong element of faith. The flood geologist cannot expect to prove that God caused a flood, but he can hope to demonstrate that hypotheses based on the biblical flood account can stimulate productive research and produce more adequate explanations for geologic phenomena. As this process achieves success toward demonstrating that much of the geologic column was deposited catastrophically, it will indicate to an open-minded person that it is not at all unreasonable to believe in the Bible.

There is another important aspect of this topic that cannot be experimentally studied but can be dealt with only on a philosophical level. The scientist understands the universe as a complex physical system that functions according to natural laws. Many scientists would insist that for God to cause a worldwide flood would be a miracle, and miracles are some sort of magic, contrary to natural law, and thus unscientific. That would be a reasonable assertion only if we are willing to believe that science has discovered all natural laws; that there could not be any undiscovered laws which God could use to perform His "miracles." To make that claim is hardly even rational! There is

much about the universe that we do not know. Whether God ever does operate outside of the laws that govern the universe is something that we cannot know for sure, although it appears likely that He does so rarely, if ever. The one thing that seems certain is that it is not reasonable to assert that God cannot work outside the natural laws *that are known to us*. There could be many laws which are far beyond our present state of knowledge, which God could use to accomplish His purposes.

Another aspect of this same issue can be best explained with an example. I can hold a book in the air and drop it, and the law of gravity dictates that it will fall to the floor. However, since I am a mobile, reasoning being, I can decide to stick out my hand under the failing book. I have interjected an outside force into the system and changed the course of events, but I have not broken any laws. God could decide to interject an outside force into earth's balanced geologic system and change the course of events to bring on a flood, without breaking any laws of the universe. One has only to be willing to admit that such a powerful and knowledgeable Being could exist in the universe: a Being who understands all natural law, and, in fact, made all natural law.

RESOLVING THE CONFLICT BETWEEN SCIENCE AND RELIGION

In some fields of science, such as physiology and many areas of chemistry and physics, there is no conflict between science and religion. These sciences either complement the Bible or deal with subject matter that is not discussed in the Bible at all. In paleontology, geology, evolutionary biology and other fields, we see severe conflicts between the claims of science and the teachings of the Bible. These conflicts lead us to ask the question — what roles do science and religion each play in our search for truth? Must we accept science and reject the Bible, or vice versa? Or is there a better way?

The scientific process is a good way of discovering truth, both in some areas that the Bible discusses and in areas that the Bible doesn't mention. Science is a slow process, with many human limitations, but still very effective. Science suggests explanations for the things we observe in nature and collects research data to test the validity of those explanations. Usually we do not have enough data to be completely certain that we have the correct explanation, or theory, but the data help to eliminate some of the incorrect theories. For example, there was a time when nutritionists knew that certain general types of food seemed to be beneficial, and some substances were definitely harmful, but not much was known about specific nutritional requirements, or about parasites, some vitamins, cholesterol and other important dietary factors. Thus, within the limits provided by known facts, there was still a broad range for theories about diet.

As continued research has given us more knowledge about physiology and nutrition, this increased knowledge has shown that some of the old theories

were wrong. Thus we see that the more inadequate our data are, the more room there is for uncertainty as to what is correct theory. As more data accumulate, more incorrect theories are shown to be wrong, and our range of uncertainty is reduced. We can illustrate these principles with a diagram (Figure 1).

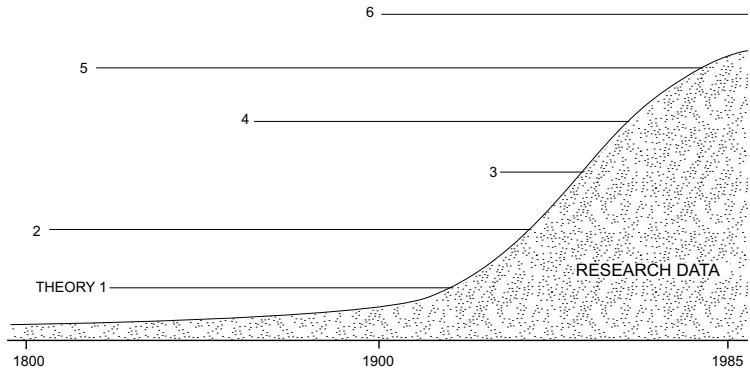
As more data accumulate, the new data not only eliminate false theories, but they also enable scientists to develop new theories that they had not thought of before. These new theories may be stepping stones to even better theories, or they may stand the test of time and turn out to be correct.

Let us now look at another example, in the field of geology. Prior to 1950, sedimentary rocks composed of coarse-grained, graded beds (Figure 2) were believed to have been deposited slowly, in shallow water. For instance, the Pliocene rocks in the Ventura Basin, near Ventura, California, consisted of hundreds of graded beds. The evidence indicated that these layers were deposited in shallow water, and it took several years to deposit each layer (Eaton 1929).

Then in 1950 a paper was published, reporting the discovery of a previously unknown phenomenon — turbidity currents (Kuenen & Migliorini 1950). Turbidity currents are rapid underwater mudflows that can deposit a layer of sand or mud over a large area. The layers produced by turbidity currents are called turbidites, and they are often graded.

Turbidity currents provided an even more satisfactory explanation for the graded beds in the Ventura Basin, and the entire sequence of beds was

FIGURE 1. A diagrammatic representation of the relationship between theories and data. In this diagram and in Figures 3 through 5, the height of the stippled area at any given date represents the amount of data available at that time. Horizontal lines represent the lifespan of various theories. A theory's lifespan ends by "collision" with accumulating evidence that contradicts the theory, or by radical alteration (a scientific revolution, represented by a vertical line) into a new theory which is not contradicted by the available evidence.



reinterpreted as a series of turbidites (Natland & Kuenen 1951). Each graded bed was now understood to have been deposited in minutes rather than years, and in deeper water. This change in theory can be illustrated with another diagram (Figure 3). The change was brought about by the accumulation of new data; the discovery of previously unknown processes.

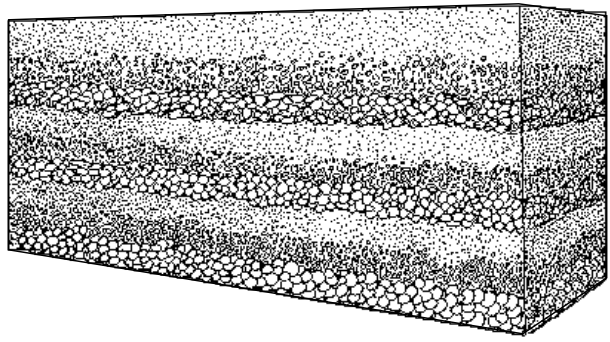
Many such changes have occurred in the history of science and many more will undoubtedly yet occur as new discoveries are made, even discoveries related to phenomena we have not yet dreamed of. Science is always a progress report on the road to truth, not final, absolute truth. In contrast to that, the Bible claims to deal with truth and to have originated with the God who has seen it all — who understands all of earth history and all natural laws. How does a scientist relate the two? Each scientist must decide how much confidence to place in the Bible, and to what extent science can "correct" the Bible.

The many possible approaches to the relationship between science and Bible-oriented religion can be summarized by the following partial list (loosely adapted from Watts 1976).

1	2	3	4	5
science only	science and biblical faith separate	dualist:science and Bible	Bible superior	Bible only

1. Science is the only reliable source of information. This model maintains that the Bible may contain inspirational religious concepts, but these are only relative and allegorical. The Bible is not a source of reliable facts. The person who accepts this view reinterprets or disclaims anything in the Bible that conflicts with current scientific interpretations.

FIGURE 2. A block diagram showing a cross-section through three graded sedimentary beds. In each bed, the larger particles are at the bottom, and the smaller particles at the top.

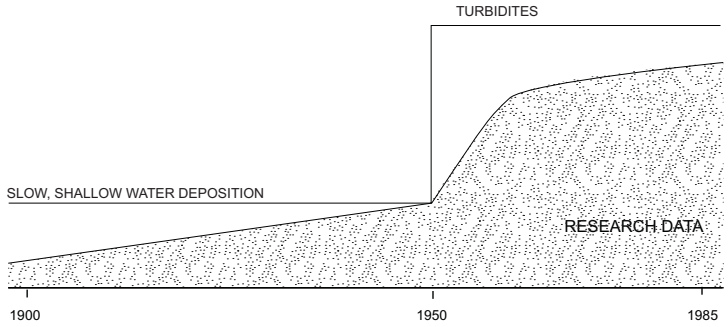


2. The Bible is taken more seriously than in model #1, but science and biblical faith are kept in two separate compartments, and no attempt is made to relate one to the other.
3. The dualist recognizes a type of authority in both the Bible and science, and takes both sources seriously in the search for truth. Conflict between the two arises only because of human limitations in the scientific process and/or in our understanding of the Bible.
4. Science and the Bible are both taken seriously, but the Bible is granted a higher level of authority than science.
5. Only the Bible is accepted as being reliable. This extreme view tends to reject all of science as a tool of the devil, designed by him to destroy faith.

Of the five models described above, #1 and 5 represent the easiest ways to make a decision. They are essentially all-or-nothing approaches, and do not necessarily require much careful thought. I do not believe that either one realistically comes to grips with the problem.

Model #2, keeping science and religious faith separate, is a popular model and superficially seems attractive. It may even work very well for a scientist whose field of inquiry does not require him to think much about the past history of life on earth. However, what does the advocate of this model do when he encounters a Bible statement that contradicts the conclusions of science? When faced with such a contradiction, the Christian scientist can no longer keep the two sources isolated in separate compartments, without putting his mind in neutral. He will then, even though he may not realize it, or may even deny it, move from model #2 to one of the other models. Consequently, Model #2 has failed at the very point where we need a model to help us direct our search for truth. A number of different models can work equally well in areas where

FIGURE 3. A diagrammatic representation of the change from the shallow water theory of graded bed deposition to the turbidite theory. This change occurred through a scientific revolution stimulated by the accumulation of new data.



science and the Bible do not conflict. It is when conflict arises that the relationship between the two sources of information becomes significant. Model #2 merely avoids the issue, or pretends that it doesn't exist, and thus I conclude that this model is not worthy of further discussion.

Model #3 and 4 are similar, except that Model #4 places more confidence in the Bible and man's ability to correctly understand the Bible, than in man's ability to correctly interpret scientific data. This difference is likely to be more pronounced in areas of philosophical conflict, such as theories of origins.

I propose that the most fruitful approach to the study of origins and of earth history is found somewhere between Models #3 and 4. Furthermore, I believe that one of the most crucial features of either of these models will be its definition of the approach to be taken in resolving conflicts that arise between science and religion; between our interpretation of revelation and our interpretation of scientific data. The remainder of this paper proposes an approach to resolving such conflicts.

SCIENCE AND REVELATION: A WORKING RELATIONSHIP

With Christianity there are many different attitudes toward the authority of the Scriptures, but this paper is built on a conviction that there are many lines of evidence indicating that the prophets do indeed speak for a loving and all-knowing God whom we can trust, and whose prophetic messages we can trust. Within that framework, an effective working relationship between science and revelation can result if we proceed through the following steps in our attempts to understand truth:

1. The accumulating data from scientific research suggest new ideas or hypotheses that we might not have thought of if the research had not been done.
2. If the new idea involves a subject that we think the Bible may speak about, we would examine all relevant Bible texts, comparing Scripture with Scripture, and using the Bible as its own interpreter. In doing so, it is important to make use of all the latest information that helps us to research a correct understanding of the original meaning of the words used in the biblical manuscripts. In this way, we attempt to understand exactly what the Bible does or does not say about our new idea. Is the idea compatible with the Bible or not? Do the relevant Bible statements say what we thought they said, or have we been incorrectly reading something between the lines?
3. We then make one of the following decisions, or some appropriate variation of one of these:

a. It is evident that revelation does not speak to this issue at all, and does not help us in our research.

b. We conclude that revelation does address this topic, but does not say anything against the new idea; there is no biblical reason not to accept it as a valid possibility. We then proceed with further scientific research to rigorously test it. This research may give us increased confidence in the idea, or it may lead to even better hypotheses which would also need to be compared with the Scriptures.

c. Our study indicates that revelation clearly contradicts the new idea, thus telling us to go back and do some more research because there is something wrong with our interpretation of the data.

If we follow this process, the Bible is maintained as the standard for religious doctrines, and yet science and the Bible shed light on each other. Science suggests ideas that may help us to recognize that we have been reading some preconceived idea into the Bible that really is not there. In other cases the Bible can help us to recognize incorrect scientific theories, so that we can turn our efforts toward developing more accurate interpretations of the data.

EXAMPLES

The following examples illustrate the application of this approach to some current conflicts between science and religion, and to some past conflicts which I believe could have been avoided if the individuals involved had followed this same approach to the problem.

The Copernican revolution in astronomy. Long before the Middle Ages scientists had developed the theory that the earth is the center of the universe, and all other heavenly bodies rotate around our earth — the geocentric theory. This concept was not merely a bit of fuzzy superstition, but was a carefully developed theory with sophisticated mathematical models describing the movements of stars and planets, supported by volumes of observational data (Kuhn 1957, Ptolemy 150). As the Christian church developed, the geocentric theory eventually became incorporated into church dogma, to the point that a challenge to the geocentric theory was considered to be a challenge to the Scriptures and to the Church itself. Copernicus introduced a new theory — the heliocentric theory. According to his radical new idea, the earth and the other planets rotate around the sun. If the church, instead of persecuting the advocates of the heliocentric theory, had gone to the Bible and studied carefully to see if the Scriptures actually say anything about these theories a serious mistake could have been avoided. They would have found that the Bible does not address itself to the issue of whether the earth rotates around the sun or

vice versa. To attempt to support the geocentric theory from the Bible can only be done if one resorts to arguments akin to saying that 20th-century scientists must believe in the geocentric theory, because they speak of the sun rising and setting. Careful Bible study could have indicated that the heliocentric theory is not unbiblical, and science and Scripture could have worked together in exploring this issue instead of being antagonistic to each other.

The theory of evolution. Previous to the 19th century, scientists and others generally believed that animal and plant species do not change — every species has remained the same since it was created. The Church again incorporated contemporary scientific thought into church dogma, and assumed that the Genesis creation account supported this very static concept of nature — referred to as "fixity of species." Charles Darwin and his contemporaries saw evidence that animals and plants do change, and started another conflict between science and the Church. Because of the complexity of the evolution issue, I will discuss the conflict in two parts: (a) The theory that organisms do change, resulting in variations within created groups, and (b) the theory that the major groups of animals originated by evolution and not by creation.

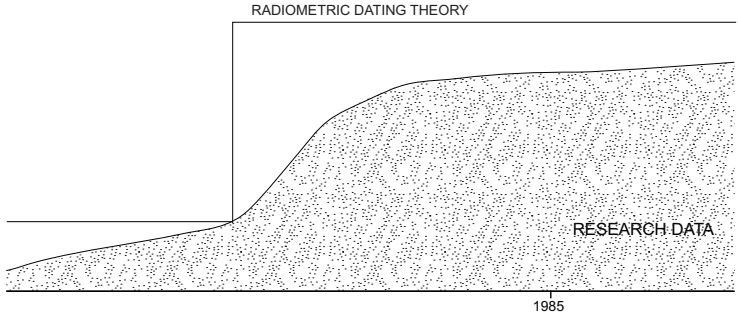
a. Microevolution and speciation. When the theory of evolution was proposed, it was generally believed that the entire concept of evolutionary change was incompatible with the biblical account of creation. But if Darwin and his contemporaries had gone back to their Bibles and studied carefully to see what the Bible says about their theory, they surely would have concluded that the Bible says nothing against the possibility that changes have occurred within the created groups of plants and animals (Coffin 1969, Ch. 3), including the production of new types of organisms to at least the species and generic level. In fact a creationist must believe that some changes have occurred, or else believe that God designed and made even the destructive things that we see in nature. However, Darwin apparently did not go back and reexamine his Bible carefully and he concluded that since his evidence invalidated what he believed to be the biblical creation account, we must explain the origin of *all* living things by some mechanism other than creation. This brings us to the second part of the evolution theory.
b. Evolution of the major groups of organisms. Darwin's theory proposes that even the major groups of living things have arisen by evolution, and thus all life is the result of evolution, not creation. If Charles Darwin had been examining his Bible and comparing it with his theory, he would have found that although the Bible doesn't say anything against microevolution, it does clearly state that the major groups of both plants and animals (including fish, birds,

reptiles, mammals, man, and fruit trees) were created by the end of creation week. This is definitely not compatible with part of the evolution theory. If the approach described in this paper had been followed, it could have led to the development of a theory which included creation of the major groups of living things, with limited evolutionary changes occurring after creation, within the created groups. Such a theory would, I believe, be consistent with Scripture and with the scientific data, and could have been an excellent example of the Bible and science shedding light on each other.

Geology. The church has been in conflict with geologists for over a century, but we will look at this issue from the perspective of the 1980s. As we compare the biblical account of origins, and scientific theories requiring many millions of years for life on earth, how can we best approach truth? I suggest that we follow the same process outlined above. Science has proposed a theory, claiming that the geologic deposits with their fossils have accumulated over hundreds of millions of years. We then go to the inspired writings to find out what they really have to say about this issue. We find that, in contrast to the absence of significant revealed information on astronomy or microevolution, the prophets made statements indicating that life on earth (and thus also the rocks containing fossils) has only been in existence for a few thousand years. We also find that during that time there was a worldwide flood of major geological significance (Brand 1980). From this I conclude that the prophets are telling us that current geological theory is not correct; the data are not being interpreted correctly. Our task is to go back to the research lab and develop a more correct theory, in harmony with both the scientific data and the revealed data.

How does one deal with data such as radiometric dating that seem impossible to harmonize with the biblical view of earth history? I propose that there are new fundamental scientific principles that are yet to be discovered

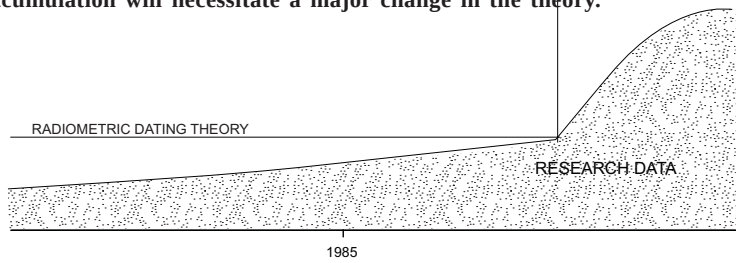
FIGURE 4. Hypothetical history of radiometric dating theory if there are no major changes to occur in the future of this theory.



that will explain these data. In doing so, we have to consider the following two propositions:

A. There are no significant new principles to be discovered in this field; the data are mostly being interpreted correctly (Figure 4).
B. There are new principles to be discovered that will lead to significant reinterpretations of data (Figure 5).

FIGURE 5. Hypothetical history of radiometric dating theory if future data accumulation will necessitate a major change in the theory.



We must now ask whether we have data that will allow us to test between propositions A and B; to determine whether radiometric dating theory is comparable to theories of graded bed deposition *after* the discovery of turbidites, or *before* their discovery. If science could do that we would have the key to answering a lot of difficult questions, but science cannot test between A and B. To do so would require that we go into the past and observe what really happened, or go into the future and see what data will be available then, or talk to someone who has done one of these. The prophets claim to have some of that type of information, but science definitely does not. Consequently, science cannot test between A and B.

Since we cannot prove which is correct, A or B, should we assume that A is correct, if there is no definite evidence for B? Science would normally take that approach, but we must remember that that is only a practical working approach, not a method for determining truth. A scientist must push ahead with the most successful theory available at the time, trusting that the data will eventually tell us if the theory is wrong. That approach may not be satisfactory for a Christian as we compare the Word of God with current scientific theories, and make decisions regarding eternal truth.

The history of science does not support the notion that a well-developed theory must be true if at a given time there is little or no convincing evidence against it. Before the discovery of turbidites there seemed to be good evidence that the then-current theory was correct. Even as some problems with that theory began to appear, scientists did not have the information necessary to

envision a better explanation, until turbidites were discovered. A Christian who is convinced that there is sufficient evidence that God's revelations to us through His prophets are trustworthy will be led to believe that in the field of radiometric dating there must be one or more important discoveries yet to be made, of equal or greater significance than the discovery of turbidites.

I conclude that a decision in favor of the current scientific interpretation of radiometric dating and a decision against that interpretation are both made on faith. A person with more faith in current scientific theories than in revelation will likely conclude that radiometric dates as currently interpreted are accurate. However, a person whose faith in the prophetic writings is stronger than his faith in current scientific theories will be convinced that radiometric dates of fossiliferous deposits are not correct. If he goes a step farther and uses the scientific method to develop and to test new theories to explain radiometric phenomena and other data, scientific progress can result from our search for harmony between science and revelation.

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NEWS AND COMMENTS

CALIFORNIA SCIENCE TEXTBOOKS

In September 1985 the California State Board of Education (CBE) rejected science textbooks proposed for adoption. Two CBE members believed the textbooks contained "too much evolution already" and urged the textbook panel to comply with a 1981 court order by removing dogmatic assertions in behalf of evolution. The other seven CBE members felt that the science textbooks had failed to follow the State Board's model curriculum because they systematically omitted such controversial topics as evolution and human reproduction. All CBE members concluded unanimously that the proposed science textbooks for elementary and junior high schools must be revised before they can be approved for adoption.

This decision is important because California accounts for about 11% of the U.S. textbook market and approves textbooks for use over a multi-year cycle. Because publishers find it too costly to produce multiple editions of a given text, California's selections are likely to become standard for the nation. Bill Honig, state Superintendent of Public Instruction, cited the rejection of science textbooks currently offered by publishers as the culmination of an 18-month effort to set higher standards for content. Acknowledging that the same demands for quality would be placed also on textbooks for other areas, he predicted, "The reality is that we are establishing a policy for the rest of the country as well."

Although the CBE had never before rejected textbooks on the basis of inferior quality, their decision was not unexpected. In July a state education review panel comprising school officials and teachers reported that "no single textbook series was judged to be excellent in all respects" and recommended that some be rejected and that others be accepted with the proviso that they be revised to include thorough discussions of evolution, human reproduction, and environmental and ethical issues.

Not wanting to lose the lucrative California market, most publishers agreed to comply with the decision, despite the imminent deadline for revisions and the high costs of making changes. In the area of human origins, they will have to walk a tightrope in order to meet the demands of the CBE and still avoid violating the 1981 court order against dogmatic presentation of evolution.

Katherine Ching

LITERATURE REVIEWS

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

EVOLUTION DEFENDED

ABUSING SCIENCE: THE CASE AGAINST CREATIONISM. 1982. Philip Kitcher. Cambridge, MA and London: MIT Press. 213 p.

Reviewed by L. James Gibson, Geoscience Research Institute

"This book is intended to be a manual for intellectual self-defense, something that can be consulted when the smiling advocates of Creationism launch their attack" (p 4). The purpose of Kitcher's book is clearly stated. Although he does not accept a literal reading of Genesis, Kitcher is not trying to "debunk religion" (p 6). "My business is strictly with a political movement," he says (p 6), aimed specifically at the "Moral Majority" and the Institute for Creation Research (p 1, 6). His strategy is first to refute the criticisms of evolution by creationists and then to turn these criticisms back at creationism.

Chapter one is a brief summary of the main tenets of evolutionary theory. According to Kitcher, "the main thesis of evolution is that species are not fixed and immutable" (p 7). Since Kitcher knows that creationists agree with this statement (p 143), this seems to be an odd way to begin explaining the differences. In chapter five, Kitcher examines creation theory itself to see how it measures up as science. The final two chapters are more concerned with the politics of the debate and the real reasons creationists are upset with evolutionary theory.

The criticisms of evolution by creationists discussed by Kitcher can be arranged into three main arguments: 1) evolution is not really science; 2) evolution is implausible on theoretical grounds; and 3) evolution is not well-supported by the evidence.

Four points are included in the argument that evolutionism is not true science. The first two points are that evolution cannot be proved and that it cannot be falsified. Kitcher's response is that science is not a matter of proof, but of evidence (p 32-35). To him, the evidence clearly favors evolution. As for falsifiability, "naive falsifiability" is not a good criterion for science (p 42-44), but evolutionary theory has produced many hypotheses which are falsifiable (p 60-63). (Kitcher does not seem to notice that a hypothesis can be falsified without testing the theoretical setting in which the hypothesis was

generated). The third point is that evolutionary theory cannot predict the future. Kitcher responds that evolution does not claim to predict the future, but it does make (testable) predictions, such as the existence of marsupial fossils in Antarctica (p 80). To the criticism that evolution is tautological, Kitcher replies that although natural selection can be stated as a tautology, the principle of natural selection is not tautologous, and evolutionary theory is much more than natural selection (p 55-60).

The argument that evolution is implausible on theoretical grounds has three main components. The second law of thermodynamics states that "the entropy [disorder] of a closed system increases with time" (p 90). Creationists have used this law to support their contention that order will not be produced by random processes. Kitcher's answer has two parts. Entropy can decrease in an open system (p 89-96). Since living things are not closed systems, they can increase in complexity (p 92). (Probabilities are not discussed in this context). The second part of the answer is that events which appear random are not necessarily chaotic. In fact, they may have a deterministic basis which would enable us to predict the outcome if we knew enough about the starting conditions (p 86). Kitcher here appears to be a reductionist (see also p 105-106). However, his attempts to defend the hypothesis of the abiotic origin of life seem half-hearted and unconvincing (p 75-78).

The other two points included in this second main argument are that mutations are harmful rather than helpful, and that even if organisms did change gradually by the accumulation of mutations, the changes required to account for the present diversity of living organisms would require far more time than anyone has postulated. Kitcher replies that whether a mutation is harmful or helpful depends on the genetic background and physical environment of the organism carrying it. The problem of lack of time is addressed by appeal to the familiar (and irrelevant) card-drawing scenario (p 103). Pick any 13 cards from a deck, then compute the probability of selecting them in that order. The probability is a very small number indeed. Yet that improbable event occurred. So evolution, although it may be improbable, has also occurred. Kitcher attributes the occurrence of such improbable events, including the evolution of horses (p 103) and the origin of life (p 105), to the inevitable result of the initial state of the system. It is not clear whether he believes that life and its diversity are the result of some kind of biochemical predestination.

The third creationist argument against evolution is that it is not well-supported by the evidence. Two principal criticisms are involved here. The failure of the fossil record to show a graded series connecting all forms of life is attributed by Kitcher to the nature of the fossil record. It is partial, with many missing time gaps, and it is biased, favoring certain taxonomic groups, especially those with hard parts which are easily preserved (p 107). Despite the incompleteness of the record, there are partial series of intermediates,

such as between fish and amphibians, reptiles and mammals, and reptiles and birds (p 108-117). The other criticism is that evolutionary novelties could not become established gradually because they would be selected against unless they were fully formed. Kitcher responds that complex structures can be formed gradually through natural selection if they are linked to a useful character, are partially useful, or are useful in a different way (p 119). (No examples are given).

In chapter 5, Kitcher turns the arguments back onto the creationists. His criticisms of creationism can be divided into two main arguments: 1) creationism is not science; and 2) creationism is not well-supported by the evidence.

Several specific criticisms are used to support Kitcher's first argument. Creationism is not science because it does not permit tests of falsifiability, but appeals to the miraculous when problems are encountered (p 134, 181). Creationism is not based on observation, but on the Bible (p 180). Creationism has no explanatory value and virtually no problem-solving strategies (p 124-127, 171). Rather, creationists selectively borrow from evolutionary studies (p 144, 164). Finally, creationism has no theories of its own (p 126), but largely confines its activities to attacking evolutionism (p 126, 176).

The second argument, that creationism is not well-supported by the evidence, is illustrated with five examples. Kitcher asserts that the order of fossils in the rocks is not explained by the Genesis flood (p 131). In addition, there is no mechanism proposed for the flood (p 132). The next target is the concept of design. What is the "Grand Plan" of creation? asks Kitcher (p 138). Why did God need to design defenses against predators? (p 137). Next Kitcher questions the adequacy of dispersal from Ararat to explain the present biogeographical distribution of mammals (p 140-143). What scientific evidence is there for only one ark? Why did Australia become a stronghold for marsupials?

The fourth point which Kitcher wishes to discredit is the creationist belief that many original "kinds" of animals were created and that changes since creation have been limited to producing varieties of a "kind," but no new "kinds." Kitcher maintains that there is no substance to the creationist claim that microevolution and macroevolution are different processes (p 144). Even if a difference should be discovered, the "fact" of evolution would still not be refuted (p 150-151). Creationists are accused of "crude gerrymandering" in their definition of what constitutes a "kind" (p 153). Faced with inconsistencies in their application of the term, Kitcher accuses creationists of retreating into vagueness (p 154). The final criticism of creationism concerns the age of the earth (p 155-164). The evidence from radiometric dating is alleged to be consistent with the theory of evolution but not consistent with creation theory.

The final two chapters are based on Kitcher's conclusion (p 164) that creationism is not science at all. He does suggest (p 173, 174) that it might provide a useful classroom example of pseudoscience. He also asserts that if creationism is required in the public schools, then space should also be made available for other "sciences," such as those of the Muslims, Hindus, and even the Druids!

Perhaps the most damning comments made by Kitcher about creationists are found at the end of the book. He states that "for the Creationists, misleading quotation has become a way of life" (p 181). And, in rebuttal to the accusation of some creationists that evolution is the source of the evils of this world, Kitcher replies that "the most popular doctrine for use in rationalizing evil and immoral actions has surely been Christianity" (p 197), and supports the charge with a list which includes anti-Semitism, the Inquisition, witch-burning, and other church-sponsored activities. With this history in mind, it should not be surprising that the scientific community wishes to maintain its own identity separate from that of organized religion. However, it could be that such evils as Kitcher points to are not the result of religion, but of the human condition, to which scientists themselves are not immune.

How shall I evaluate the book? Kitcher has probably done as well as anyone in answering the challenge from creationists. His defense of evolution is spirited, even where it is weak. He has a tendency to make statements of victory without a convincing argument (e.g., p 115, 119, 144). (This may reflect differences in philosophies). His criticisms of creationism are of mixed validity. In arguing that creationism is based on religion, I must agree. Whether that excludes creationism from the realm of science depends on the definition of science. Evolutionists have defined science in such a way as to exclude God, but there is no requirement that it be so defined. The conclusion is contained in the definition. The criticism that the evidence does not support creation theory is unconvincing. Much of the evidence does not support any present theory, or can be explained by either theory. One can still make a choice as to which explanation of our existence makes the most sense. It seems reasonable to me to base this decision on evidence from all areas of one's experience. Like many others, Kitcher appears to miss the distinction between testing a paradigm and testing specific hypotheses generated from within that paradigm, Nevertheless, Kitcher has pointed out some areas of creation theory which need further study and development. It is hoped that research programs will be designed to test competing hypotheses and fill in some of the gaps in creation theory.

ANNOTATIONS FROM THE LITERATURE

Bada JL. 1985. Amino acid racemization dating of fossil bones. Annual Review of Earth and Planetary Science 13:241-268.

Summary. An up-to-date review of amino acid dating by a recognized authority on the subject. The introduction contains an explanation of the racemization process. The main text summarizes the amino acid dating of fossil bones from Olduvai Gorge (East Africa) and paleoindian sites in California (USA).

Comment. The author's conclusion regarding the reliability of amino acid age estimates as an accurate indicator of real-time fossil age provide both agreement and contrast with the conclusions presented in *Origins* 12:8-25, 1985.

Bethell T. 1985. Agnostic evolutionists: the taxonomic case against Darwin. Harper's 270(February):49-52, 56-58, 60-61.

Summary. A non-technical account of the controversy between cladistic evolutionary biologists who question the validity of the study of ancestral forms and the neo-Darwinists who follow more traditional lines. A number of thought-provoking questions are raised.

Cohen IL. 1984. Darwin was wrong — a study in probabilities. Greenvale, NY: New Research Publications, Inc. 225 p.

Summary. The author introduces in a simple style the concepts of probability and their application for evaluating concepts of the origin of biological systems. He shows how highly improbable it is that they could have arisen spontaneously. He then presents evidence of design using a number of complex biological systems as examples. The book concludes with a discussion of the implications of belief in evolution.

Davies P. 1983. God and the new physics. NY: Simon & Schuster, Inc. 225 p.

Summary. A thought-provoking analysis of the impact of the new physics on religious ideas. Some biological and cosmological concepts are also considered. In a lucid style the author, who is sympathetic to the concept of a God, presents various possibilities and few conclusions.

Godfrey LR, editor. 1983. Scientists confront creationism. NY and London: W. W. Norton & Company. 324 p.

Summary. A symposium volume with 15 contributors who address some of the main issues between creation and evolution. The authors, many of whom are world authorities in their field, are strongly sympathetic to evolution. A good reference for those interested in the evolutionary answers to some creationist challenges.

Comment. This is one of the more scholarly and least polemic of the recently published anti-creation books.

Hammer RE, et al. 1985. Production of transgenic rabbits, sheep and pigs by microinjection. Nature 315:680-683.

Summary. A human growth gene, previously transferred into mice and inherited by their offspring (Nature 311:65-67, 1984), has been transferred to rabbits, pigs and sheep. Will man be able to "create" better species? or new species?

Klemke ED, Hollinger R, Kline AD, editors. 1980. Introductory readings in the philosophy of science. Buffalo, NY: Prometheus Books. 373 p.

Summary. A compilation of 23 short essays on the nature and meaning of science. The last seven essays deal with the relation of science to human values. Most of the essays are reprints of classic publications by noted scientists or scientific philosophers. An easily understood and stimulating volume.

Taylor IT. 1984. In the minds of men. Toronto: TFE Publishing. 498 p.

Summary. A comprehensive and authoritative (except for chapters 11 and 12) review of the controversy between science and the Bible. A good source reference for many of the current issues. The author, who is sympathetic to the creation viewpoint, provides a rich background of information.

GENERAL SCIENCE NOTES

WHICH VERTEBRATES MAKE VITAMIN C?

By Elwood S. McCluskey, Associate Professor, Departments of Physiology and Biology, Loma Linda University

WHAT THIS ARTICLE IS ABOUT

Vitamin C is involved in the body functions of both man and animal. But it was long believed that man and a few exceptional animals like the monkey and guinea pig were the only ones that require the vitamin in their diet; the rest can make their own. Chickens do not require the vitamin, so presumably birds in general do not.

But careful investigation has revealed that many species of birds must get the vitamin in their diet; and of those which make their own, some make it in the kidney and some make it in the liver. When more mammals were studied, there were additional surprises. For example, all the members of one order require the vitamin.

Only now do we have sufficient knowledge of the diversity in vitamin C requirement to even begin an evaluation of the various possibilities for the origin of that diversity. Could this be true also of other characteristics of animals? Might we sometimes be too hasty in concluding that there is conflict between revealed and scientific avenues of information on origins?

No one would question that vitamin C (ascorbic acid) is of critical importance in body function. But the distinction between animals which can make their own and those which require it in the diet is only now recently becoming known.

The standard comprehensive reference on comparative physiology (Prosser 1973) states that ascorbic acid is synthesized in adequate amounts by most vertebrates, though required in the diet of man, monkeys, and guinea pig. An earlier text (Scheer 1948) listed the same mammals, and also those mammals and birds which had been shown *not* to require it: rat, mouse, hamster, cow, cat, dog, fox, and chicken.

In 1969 Chaudhuri & Chatterjee showed that if one group, the birds, is studied in detail, the picture becomes more complex and interesting. However, the data were partially obscured by the heavy emphasis on phylogenetic theorizing, both in the brief text and in its accompanying diagram. One species each from 11 orders was studied; 10 of these were able to synthesize ascorbic acid in the kidney, and 1 in the liver. In a 12th order (the "perching birds" that we most often see) 10 species could make the vitamin in the liver, 2 in both liver and kidney, and 16 in neither organ. Later Chatterjee (1973) and

Gupta et al. (1973) tested reptiles (all in the kidney) and mammals (in the liver, in neither organ — guinea pig, monkey, man, 2 bats).

In the last half of the decade three comprehensive papers on mammals appeared, all by Birney et al. (1976, 1980) and Jenness et al. (1980). They could detect the critical synthesizing enzyme for ascorbic acid in only 1 of the 34 species (6 families) of bats studied, and there only a trace was present. This deficiency is evidently not due to lack of importance of the vitamin to the animal: in the several genera of bats checked, the tissue level of the vitamin was the same as in other mammals.

These same authors found the enzyme in the liver of all but one (guinea pig) of 49 species (5 orders) of eutherian mammals. And they finally discovered some exceptions to the liver as the site for synthesis in some non-eutherian mammals: in monotremes it is the kidney (2 species); and in marsupials, synthesis may occur in both kidney and liver (2 species), or in the liver only (15 species, 7 families).

How might all this diversity with respect to ascorbic acid synthesis in the vertebrates be explained? Is there evidence for a taxonomic explanation? First I arranged literature records by taxon. Then diversity was analyzed at each level, using different members of a taxon to check whether it consistently differs from other taxa at the same level: e.g., orders as replicates for each class to determine whether the vertebrate classes are alike or different; or species as replicates for each genus to determine whether genera are alike or different.

Between classes of a phylum. In fish, amphibian, and reptile classes synthesis (if it occurs at all) is by the kidney in the few representatives studied, but in two orders of birds and most orders of mammals it is by the liver. Birds and mammals differ significantly in the proportion of orders which synthesize by the kidney or by the liver (Table 1).

TABLE 1

Distribution of critical enzyme involved in ascorbic acid synthesis: number of orders of birds or mammals in category specified.

Class	Kidney Synthesis	Liver Synthesis	Neither
Bird*	11	2	1
Mammal*	2	9	2

*12 orders of birds reported: 1 of these orders is represented in all 3 columns, 11 orders of mammals reported: 1 of these is represented under both Kidney and Liver; and 2 are represented under both Liver and Neither (cf. Table 2).

Between orders of a class. Mammals (see Table 2). The number of species measured in Monotremata (two) is small. But each represents a different family (platypus and spiny anteater), and they are alike in being the only mammals where synthesis is by kidney alone. The two taxa sampled in the marsupial order Peramelina are alike in being the only mammals where it is by both liver and kidney. One order as a whole (Chiroptera) seems to lack synthetic ability. All the families tested (5) from one suborder of Primates lack the ability, whereas those (2) from the other suborder make the vitamin in the liver.

Birds. In the one order where many replicates have been tested, there is much diversity: 4 families make the vitamin in the liver only, 2 in both the liver and kidney, and 9 in neither. This is in marked contrast with the other 11 orders (1 or 2 species each) taken as a whole, where it is the kidney in every order but one.

Between families of an order. In the one family of birds with records for as many as 3 genera, 1 genus can make vitamin C in both liver and kidney, but the others only in the liver. The same is true for one of the two families with 2 genera each. This suggests as much diversity within a family as within the order itself; but a multi-genus test of only 3 families is obviously inadequate. (In the other classes there appears little diversity to explain at this or the next taxonomic level).

TABLE 2

Number of families of mammals having at least 1 species with site of vitamin C synthesis indicated.

Order	Kidney synthesis	Liver synthesis	Neither
Monotremata	2		
Marsupicarnivora (marsupials)		2	
Peramelina (marsupials)[a]	1	1	
Diprotodontia (marsupials)	1[b]	5	
Insectivora		2	
Chiroptera (bats)		1[c]	7
Primates		2[d]	5[e]
Carnivora		5	
Lagomorpha (rabbits)		1	
Rodentia		9	1
Artiodactyla		3[f]	

[a]The 1 family reported is represented under both Liver and Kidney
[b]Trace of 1 of the 5
[c]Trace of 1 of the 7
[d]Prosimians
[e]Anthropoids
[f]Low

Between genera of a family. In one family of birds there are 3 genera represented by more than 1 species each. In 2 of these genera, the species are alike in being incapable of synthesis. But in the third genus 1 of the 2 species makes the vitamin in the liver only, and 1 in both liver and kidney. Hence this basic a difference can occur within a *genus*. Thus the limited sample available does not demonstrate between-genus or between-family (above) diversity to be taxonomic.

Would diversity in food habit explain any of the diversity in synthetic ability? Birney et al. (1976) felt that their sample of 34 species of bats might help answer this question, especially because the bats represent groups with very different diets: fruit, pollen-nectar, blood, fish, insects. Yet all the species turned out to be alike in synthetic disability. The authors point out that one type of food known to be deficient in ascorbic acid is seeds, and no bat relies on them as its primary food.

Is this pattern produced by degenerative loss of synthetic capability? The evidence indicates that it is. For one, the distribution of deficiency is sporadic: one species (guinea pig) out of many species and families of rodents; 2 out of 7 individuals of one species of marsupial (Birney et al. 1980); and a synthetic capacity in one species of rabbit so low that the vitamin is probably a dietary requirement (Jenness et al. 1978). In the words of Hoar (1975), "loss of the enzyme concerned with ascorbic acid has evidently occurred quite frequently."

In conclusion, what has the study of many more taxa done? 1) It has greatly enriched our picture: rather than the long-held view that vitamin C is required in the diet of guinea pig, monkeys and man, we now see that it is required also by bats, at least some fish, and many birds; and on the other hand, not by all primates. Further, animals which make their own do so in different organs: the kidney, especially reptiles and birds; or the liver, especially mammals and perching birds. 2) There is evidence for a taxonomic explanation of part of the diversity between classes and between orders, but hardly data at lower taxonomic levels even to carry out a common statistical test. 3) It appears to provide more support for change by loss than by gain of capability.

Were all animals once able to make their own vitamin C? or were they all dependent on their food for it? or some of both? Would original design plus degenerative loss serve to explain the present-day diversity? In any case, we see here a current example of how more research can greatly change our understanding of diversity. This should make us slow to conclude that scientific and revealed information on origins actually conflict.

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