

# EDITORIAL

## DEUS EX MACHINA

*Well over a century ago, some were of the opinion that only God could create organic compounds such as sugars, proteins, urea, etc. These molecules, which are comparatively complex, were usually associated with living organisms and the mystery of life. Since that time, many thousands of different organic compounds have been synthesized, and God is no longer considered necessary for this process. In the cosmic realm, Sir Isaac Newton thought that God would have to occasionally adjust the universe to keep it operating properly. This idea is no longer taken seriously.*

*God has been used and abused in many ways. Centuries ago He was thought to have created bedbugs to keep people from sleeping too much, and mice were thought to have been created to teach man to put food away. These ideas have also been discarded. As science has advanced, the need for God as an explanatory factor has decreased, and some now suggest that even if He exists, He is certainly not necessary. Using God to help whenever difficulties are encountered in explaining nature is often referred to a “god of the gaps,” or “deus ex machina.” The concept is usually treated with disdain, with the implication that whenever there is a problem, God is invoked to solve it; given sufficient time, science will eventually solve the mystery. God should not be used to fill our gaps in information.*

*Many scientists are also concerned about a powerful God who can manipulate nature at will and thus alter the consistency that makes science possible. In this respect, they see a genuine conflict between God and science. This conflict need not be that severe if, as was believed by the pioneers of modern science, the principles of science were created by God, and nature reflects that consistency. In their thinking, God is the author of the principles and laws of science. God can bypass the laws he has established, but only rarely does He do so. This permits science to work.*

*“Deus ex machina” is Latin for: “God from the machine.” The term stems from the practice in Greek and Roman drama of having an actor representing God coming out of the sky onto the stage to resolve major difficulties. The effect was accomplished using a crane (the machine); hence, the reference to “God from the machine” concept for resolving scientific difficulties.*

*While criticism of the “deus ex machina” or “God of the gaps” concept has some validity, to arbitrarily eliminate all of God’s activities in this*

way is oversimplistic. One needs to differentiate between the usual God of the gaps and the “God of the necessary gaps.”<sup>1</sup> For this latter case, God seems essential. The synthesis of organic compounds mentioned above would fit the “God of the gaps” concept, while the recent advances in molecular biology that make the possibility of the spontaneous origin of living things all the less plausible would support the concept of the God of the necessary gaps. In this case, it appears that God is becoming more essential as we discover more and more complex, programmed biochemical systems such as the immune system or the correcting systems for DNA replication.<sup>2</sup> How could these complex processing systems originate by themselves without intelligent design? The same can be said for the fine-tuning of the Universe that we are discovering which involves extremely precise values for basic physical factors.<sup>3</sup> The universe appears to be balanced on the edge of a knife blade.

*One should not use the fact that science has been able to duplicate some phenomena attributable to God as an excuse to eliminate God altogether, especially as we find nature to be more and more complicated and exact. God seems more necessary now than ever before.*

Ariel A. Roth

## ENDNOTES

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## ARTICLES

### THE “DAYS” OF CREATION IN GENESIS 1: LITERAL “DAYS” OR FIGURATIVE “PERIODS/EPOCHS” OF TIME?

Gerhard F. Hasel

*John Nevins Andrews Professor of  
Old Testament and Biblical Theology  
Andrews University  
Berrien Springs, Michigan*

#### IN MEMORIAM

This article is another excellent contribution by Dr. Gerhard Hasel, who for many years served as an editorial consultant to *Origins*. Dr. Hasel lost his life in a traffic accident the day before he was to make a public presentation of this article. It thus represents one of his last — if not his final — intellectual contributions to our understanding of the Bible. Unfortunately, he did not have a chance to review the final copy. Our appreciation goes to Michael Hasel for his assistance. Warren H. Johns offered constructive criticism from a bibliographic viewpoint.

We wish to dedicate this article to Dr. Hasel’s memory, with special thanks and fond memories. We are also grateful for his earlier contributions to *Origins* and for the multitude of other thoroughly researched publications that have come from his pen. His careful scholarship and unwavering faith in the truthfulness of God’s word has helped to strengthen the faith of many in the Bible.

#### WHAT THIS ARTICLE IS ABOUT

*The question of whether the six days of creation were actual 24-hour periods of time or only symbolic representations of millions of years has been debated for centuries. During the past century and a half, with recognition of the theory of evolution and its vast eons of time, the matter has been under more serious scrutiny.*

*The following article is a thorough review of this issue. The historical background and the literary nature of the creation account are discussed in detail and related to a variety of contemporary interpretations. The author concludes with ten considerations which support the concept of a literal creation week with seven consecutive, twenty-four-hour days.*

## I. INTRODUCTION

The increased focus of recent decades on creationism, “creation-science,”<sup>1</sup> “origin science,”<sup>2</sup> and “theistic science”<sup>3</sup> has created a climate in which old questions are raised anew with specific focus and additional sophistication. One of those questions concerns the meaning of the term “day” in Genesis 1:1 – 2:3.

The nature of the Genesis account of creation with its six “days” (Genesis 1:5-31) followed by the “seventh day” (Genesis 2:2-3) is of special interest, since it is customarily understood to mean a short time of one week. This short time in the creation account is under debate on the basis of the current naturalistic theory of evolution. The contrast is between the short time of the creation account and the long ages demanded by naturalistic evolution.

This paper will seek to accomplish several interrelated tasks: 1) to provide some methodological observations with a brief history of interpretation; 2) to cite representative recent published opinions suggesting that the “days” of creation are long epochs or periods of time and not literal twenty-four hour days; 3) to present the data in Genesis 1 in relationship with other data found in the Old Testament; and 4) to apply to the data of Genesis 1 the standard linguistic and semantic investigations requisite in sound scholarship based on the best current knowledge.

## II. METHODOLOGICAL OBSERVATIONS AND THE HISTORY OF INTERPRETATION

A knowledge of some aspects in the history of interpretation of the “days” of creation in Genesis 1 may prove to be helpful from the perspective of methodology for interpretation. Historical information assists the modern interpreter to recognize that it is incorrect to suggest that only since the publication of Charles Darwin’s epochal work, *On the Origin of Species* (1859), the Genesis creation “days” were transposed into non-literal periods of time. Earlier extra-biblical considerations led interpreters to depart from the literal meaning of creation “days.”

### 1. Some Medieval Understandings of Creation “Days”

The Alexandrian church father Origen (ca. A.D. 185 – ca. 254), an accomplished practitioner and defender of the allegorical method of interpretation,<sup>4</sup> is credited with being the first to understand the creation “days” in an allegorical and non-literal manner.<sup>5</sup> Augustine (A.D. 354 – 430), the most famous of the Latin Fathers, followed Origen in arguing

that the creation “days” are to be understood allegorically, rather than literally.<sup>6</sup> Augustine is understood to teach that God created the world in a single flash of a moment.

At this point it seems appropriate to reflect on some methodological matters. Neither Augustine nor Origen had any evolutionary concept in mind. They took the creation “days” as non-literal, standing for something else, because it was philosophically mandatory to assign to God creation activity which was unrelated to human time. Since the “days” of creation are related to God, it was argued, these “days” have to be representative of philosophical notions associated with God taken from their philosophical perspectives.

In Greek philosophy God is timeless. Since the creation “days” are part of divine activity, it was assumed that they also should be understood in a timeless sense. The thinking of Origen and Augustine was influenced by Greek philosophy, not by scientific speculations, which led to a reinterpretation of the creation “days.”

What this approach has in common with modern attempts, which also take the creation “days” to mean something other than what the face value of the terminology seems to suggest, is that both are based on influences from outside the biblical text itself. Medieval theologians, who took the creation “days” to be non-literal, based it on non-biblical, pagan philosophical modes of thinking.

Today there is another influence from outside the biblical text that leads interpreters to change what seems to be the plain meaning of “days.” At present it is a naturalistically based scientific hypothesis, the modern theory of evolution, which provides the impetus for such changes.

The thinking of medieval Catholic theologians was influenced by the Alexandrian allegorical method of interpretation. The fourfold sense of Scripture was adopted in medieval times<sup>7</sup> and is still supported in current official Roman Catholicism.<sup>8</sup> The three non-literal meanings of the fourfold sense of Scripture (i.e., allegory, anagogy, tropology) carried the day and held primary importance for over a millennium in Christendom, providing the hermeneutical means for the reinterpretation of the literal sense of the creation “days.”

## **2. Reformation Understanding of Creation “Days”**

The sixteenth-century Reformers agreed that the fourfold sense of Scripture compromised the literal sense of the Bible, making its authority

for faith and life null and void. They insisted that the single, true sense of Scripture is the literal sense, the plain meaning of the text.

One of the major achievements of the Protestant Reformation is the return to Scripture. This meant that Scripture is in no need of an external key for interpretation — whether that key be the Pope, the church councils, philosophy, or any other human authority. Scripture’s clarity and perspicuity became the norm of the day; its reading from within its own context was paramount. External meaning must not be superimposed on it, as had been the practice under medieval Catholicism. The Bible was to be read in its literal and grammatical sense.<sup>9</sup>

Martin Luther, accordingly, argued for the literal interpretation of the creation account: “We assert that Moses spoke in the literal sense, not allegorically or figuratively, i.e., that the world, with all its creatures, was created within six days, as the words read.”<sup>10</sup> The other Reformers understood the creation “days” in the same way.

This literal and grammatical interpretation, known in the history of hermeneutics as the historical-grammatical method, was the norm for biblical interpretation more or less into the nineteenth century.<sup>11</sup>

### **3. Changes Under the Influence of Modernism**

As the concept of long time periods made its way into the understanding of Earth’s origins in the wake of the publications of James Hutton (1726-1797) and Charles Lyell (1797-1875), some Christian concordist interpreters started to reinterpret the Genesis “days” of creation in a non-literal manner. The impetus for this was not found in the Bible itself but in the new world view which was being developed on the basis of uniformitarianism and its concomitant understanding of origins which demanded long periods of time.

The understanding of the creation “days” as “days of restoration,”<sup>12</sup> “days of revelation,”<sup>13</sup> aside from taking a “day” for an “age” (“day-age” theory) or an epoch/era<sup>14</sup> goes back to this time and the changes in time frames required by the new geology. The approach of a non-literal reinterpretation of “days” was typical of concordists who had accepted long ages for the origin of Earth.<sup>15</sup> In view of these developments, it is unavoidable to conclude that external influences exerted by a new understanding of geological ages became the catalyst for the reinterpretation of the “days” of creation.

#### 4. Recent Changes in Interpretation Among Broad Concordists

Broad concordists of the last ten years are increasingly attempting to interpret the “days” in the Genesis creation account in non-literal ways, in order to bring about harmony between the long ages called for by the evolutionary theory and the time implications of the biblical record of divine creation in Genesis 1.

It is an acknowledged fact that the long and checkered history of the relation between science and Scripture has had an impact on the present understanding of the Bible.<sup>16</sup> The shift from the Ptolemaic world view to the Copernican one is probably the most celebrated example.<sup>17</sup>

The non-Christian Ptolemaic world view had been adopted by Christian medieval theologians both as the correct Christian and biblical view of Earth. Earth was conceived as the center of the solar system, and often of the universe. It became a first-class dilemma when the heliocentric Copernican world view became prominent and seemingly irrefutable.

From a methodological point of view the interpretational model at work by the scientist as interpreter of data observed in nature will pre-determine to a large degree the outcome of the enterprise itself, as well as the meaning of data derived from non-natural sources, including the Bible. It is generally recognized that “scientific theories do affect biblical interpretation at least to the extent that they become the occasion for reassessing the interpretation of a few passages (Genesis 1-2; 6-8).”<sup>18</sup> The decisive question which emerges is whether the reassessment becomes a superimposition of a meaning on the biblical text on the part of concordists and others — a meaning which is alien to the meaning found in Scripture within its own context.

At least two major options seem to present themselves: 1) A reassessment on the basis of “scientific” conclusions could lead to an interpretation of biblical texts which is permitted within the framework of the context and intention of the totality of Scripture. In such a case the reassessment does not do violence to the internal norms of cohesion and unity of Scripture. 2) The reassessment of a biblical text could likewise lead to a conclusion regarding the specific meaning of a given biblical text or a biblical passage which does not agree with what a current scientific hypothesis holds. For those who accept full biblical authority this should lead to a reassessment of the conclusion(s) drawn from the interpretation of data in nature by the scientist. The latter, in

turn, may affect the scientific theory, or science broadly perceived, “at the very least by leading us to reassess whether all the conclusions drawn from a scientific theory are warranted, or in some cases to ask whether the theory as a whole is suspect.”<sup>19</sup>

## **5. The Inherent Authority of Scripture**

Some have taken the stance that a scientific theory, by its very nature and the breadth of its acceptance, has priority over Scripture.<sup>20</sup> It is far beyond the confines of this paper to unfold the complexity of this question. Suffice it to say that if Scripture is understood to be the result of divine revelation and written under inspiration, it would have a dimension of authority not found in the so-called book of nature. Based on that higher dimension of authority, Scripture can assist in interpretation of the book of nature, providing a more comprehensive model of interpretation than might be expected from a purely naturalistic model.

Scripture, if it is to maintain its own integrity, can hardly be interpreted in such a way as to be accommodated time and again to any kind of interpretation derived from science, sociology, history, etc. Scripture, based on its own nature and authority, has its own integrity of meaning and its inherent truth claims. They emerge ever more clearly on the basis of a careful study of the Bible with sound methods of interpretation which are in harmony with and rooted in the testimony of Scripture itself. This implies that Scripture’s authority resides in itself; it is based in revelation and grounded in inspiration.

The self-sufficiency of Scripture of which we have spoken does not mean that any question raised from other areas of investigation such as science, history, sociology and so on cannot be discussed with reference to Scripture. But there is a vast difference between asking new questions of Scripture and superimposing meaning on Scripture.

### **III. FIGURATIVE INTERPRETATIONS OF THE CREATION “DAYS”**

#### **1. Representative Arguments for Long Ages**

The clearly stated purpose of current attempts to interpret the “days” of Genesis 1 in terms other than face value is often quite clearly stated. A few citations from respected scholars will speak for themselves.

John C. L. Gibson, a British scholar, argues that Genesis 1 is to be taken as a “metaphor,”<sup>21</sup> “story,” or “parable,”<sup>22</sup> and not as a straightforward record of events of creation. He writes in his 1981 Genesis commentary as follows:



... if we understand 'day' as equivalent to 'epoch' or 'era', we can bring the sequence of Creation in the chapter into relationship with the accounts of modern evolutionary theory, and so go some way towards recovering the Bible's reputation in our scientific age.... In so far as this argument begins with an attempt to go beyond the literal meaning and to take the week assigned to Creation as a parable of a much longer period, it is to be commended.<sup>23</sup>

In 1983 the German commentator Hansj6 Brä states:

*The creation 'day' which is described to contain 'evening and evening [sic]' is not a unit of time which can be determined with a watch. It is a divine day in which a thousand years are equal to but yesterday [Ps. 90:4 in margin]. Day one in creation is a divine day. It cannot be an earthly day since the temporal measure, the sun, is still missing. It will, therefore, do no harm to the creation account to understand creation in rhythms of millions of years.*<sup>24</sup>

D. Stuart Briscoe, an American progressive creationist, addresses the issue in his commentary on Genesis as well:

*The natural scientist talks convincingly in terms of millions of years and evolutionary eras while the Bible believer looks at the six days and wonders what on earth to do.... It is not at all unreasonable to believe that 'day' (Hebrew, y6m), which can be translated quite literally as 'period,' refers not to literal days but to eras and ages in which God's progressive work was being accomplished.*<sup>25</sup>

Explanations of this kind can be duplicated and derive typically from scholars who are in the concordist camp. More precisely they belong to the branch of "broad concordists" who in recent times are associated with progressive creationism.<sup>26</sup>

## 2. Analysis and Evaluation of Psalm 90:4 and 2 Peter 3:8

**Psalm 90:4.** Let us begin with considerations concerning Psalm 90:4. This passage has been invoked time and again to indicate that the creation "days" are to be non-literal, standing for long periods/epochs/ages of time.

Psalm 90:4 reads: "For a thousand years in Thy sight are like yesterday when it passes by, or [lit. 'and'] as a watch in the night" (New American Standard Bible).<sup>27</sup> Of immediate interest is the comparison of the long time-period of 1,000 years with but "yesterday" and

“a watch in the night.” This Scripture passage contains a comparative particle in the original Hebrew to make the comparison between 1,000 years and “yesterday” and “a watch in the night.” The comparative particle is rendered into English either as “like” or “as.”

From the point of view of Hebrew syntax this comparative particle serves not only the expression “yesterday” but also the expression “as a watch in the night.” It applies to both phrases. This demonstrates that the comparison is not between a “day” being like 1,000 years. A thousand years with God are “like” yesterday, that is, the past day, or “like” “a watch in the night,” which is even a briefer period of time than “yesterday.” The point is that God reckons time differently from the way humans reckon time.

Genesis 1 is not interested in depicting how God reckons time. The Genesis context of creation speaks of “days” in the sense of creation time during which God created this world and whereby He set the rhythm of the week. Genesis 1 does not explain or address how time is reckoned on God’s scale, but how the creation “days” set the norm for subsequent days in the weekly cycle of time.

Furthermore, Genesis 1 lacks any comparative particle such as “like” or “as” in connection with the usage of the term “day.” The lack in Genesis 1 of a Hebrew comparative expression with either the term “day,” or the expression “evening and morning,” indicates that no comparison is intended. Comparison is not the issue in Genesis 1. The issue is the amount of time God uses to create the world and whether this time period is identical to the seven-day week which is the rhythm of historical time.

From contextual as well as grammatical-syntactical and semantic points of view the application of Psalm 90:4 to Genesis 1 does not work. Appropriate linguistic and phraseological criteria of comparison are lacking. Those who link the two texts are insensitive to contextual, linguistic and phraseological criteria. The impression is left that those who compare the “days” of Genesis 1 with the “yesterday” and the “watch in the night” or the 1,000 years in God’s scale of time compare apples with oranges.

Another type of objection has been noted in making the creation “days” into long periods of time: if one were to read the “sixth day as the sixth epoch of creation, this opens the door to some kind of pre-Adamic *homo* [sic] *sapiens*.”<sup>28</sup> In other words, the long-age substitution

for a literal “day” does away with the view that Adam and Eve were the first human beings which God created on Earth.

A third difficulty relates to the fact that Psalm 90 is not a creation psalm. Contextually speaking Psalm 90 does not address the issue how God regards the “days” of creation but how humans are to regard time when compared to time in the realm of God.

Fourth, Psalm 90 does not even use the term “day” by itself. It is used in a linguistic relationship in verse 4 in which two words are syntactically joined together. The English language has one word for that linguistic relationship, “yesterday.” But “yesterday” in Psalm 90:4 is in parallelism with the expression “as a watch in the night,” i.e., a very short interval of time. This means that the 1,000 years are not compared simply to a day but to a short interval of time.

In short, Psalm 90:4 does not define the meaning of the designation “day” in Genesis 1. In view of the problems cited and other difficulties that exist,<sup>29</sup> it is not surprising that many of those who currently take the “day/age theory” as a solution to the tension between science and religion refrain from referring to Psalm 90:4. This text when read on its own terms does not address the issue of the length of the creation “day.”

**2 Peter 3:8.** Broad concordists have also used 2 Peter 3:8, “... with the Lord one day is as a thousand years,” to support the day-age theory. It has been taken by some as a “biblical” mathematical equivalent “one day equals a thousand years” literally. Others take the 1,000 years to mean a long period, an age, or the like. In that case it is argued that “one day equals a long period of time” or “one day equals an age.”

It should be pointed out that those who invoke this text face several major problems: 1) 2 Peter 3:8 has no creation context; 2) 2 Peter 3:8 has a comparative particle which is lacking in Genesis 1; 3) 2 Peter 3:8 is used non-literally when the 1,000 years are taken to mean an “age” or the like; 4) 2 Peter 3:8 reveals that God is not limited to time or subject to it in fulfilling His promises.

The intent of this passage is well put by Lloyd R. Bailey, a broad concordist himself:

*The text of 2 Peter (3:8) has been misused by those who would bring it to bear upon the word ‘day’ in Genesis 1... Rather, the purpose of that text is to point out that ‘The Lord is not slow about his promise ... but is forbearing ... not wishing that any should perish ...’ (3:9; cf v. 4). That is, God is not subject to time in the sense that humans are*

(“... as some count slowness,” v. 9). The intent, then, is to make a statement about God’s fidelity to promises, and not to define the meaning of the word ‘day’ as it is used in Genesis 1.<sup>30</sup>

It seems best to let 2 Peter 3:8 make its own point and not to use it for something which is topically, contextually, and linguistically unrelated.

### 3. “Days of Revelation”?

The theory that the creation “days” are actually “days of revelation” is held by a few scholars today.

This theory was brought to prominence by the Scottish geologist Hugh Miller in the nineteenth century.<sup>31</sup> In this century P. J. Wiseman has revived it in his 1946 publication, *Creation Revealed in Six Days*, which was reprinted in 1977.<sup>32</sup>

According to this interpretation God did not create the world in six days, but He “revealed” and explained in six literal days to man what He had already done over many spans of time. The recurring phrase, “and God said,” is taken to support the theory that the “days” of creation are actually “days of revelation.” In this theory the world does not require a relatively recent origin nor creation in six literal 24-hour days.

It has been noted incisively that the “days of revelation theory,” also called the “vision theory,” rests to a large degree upon a “misunderstanding of the word ‘made’, in Exodus 20:11”<sup>33</sup> for which Wiseman claims the meaning “showed.”<sup>34</sup>

The meaning of “showed” is not a valid meaning for the Hebrew term *ʿasah*. There is no Hebrew-English dictionary which supports this meaning for this Hebrew term. The Hebrew term *ʿasah*, which is used more than 2,600 times in the Old Testament, means “to make, manufacture, produce, do, etc.”<sup>35</sup> but never once does it mean “to show” in either the Old Testament or in extra-biblical Hebrew.<sup>36</sup> The meaning “to show” is invented for the sake of the theory. In view of this fact it is not surprising that the “days of revelation theory” has not found much support.<sup>37</sup>

In summary, current broad concordists seek to interpret Genesis 1 in some sort of “figurative, symbolic, or otherwise loose reading — such as the idea that the ‘days’ of Genesis 1 may be interpreted as long periods of time.”<sup>38</sup> The purpose is to make an accommodation to current claims of the evolutionary theory for long time. Based on this time frame hypothesis, Scripture is reinterpreted to bring about some sort of harmony

between the claims of the biblical creation account and naturalistic evolution. Those who seek to make adjustments in Scripture for the sake of concordism are known as broad concordists.

In contrast, strict concordists are scholars of equal erudition and skill. They are also interested in bringing about harmony between science and religion. However, they are unwilling to give the biblical text a “loose reading.” They agree that a meaning of a text is to be based on the internal criteria of language and its usage according to the commonly accepted standards of linguistics. They agree that the context of Scripture is primary and that the linguistic standards need to follow sound grammatical-syntactical conventions. Thus, strict concordists are fully aware of the tensions but resist forcing a meaning on the biblical text that is not supported by sound linguistic analysis.

#### IV. THE LITERARY GENRE OF GENESIS 1

##### 1. Literary Genre/Form Argument

The recent Genesis commentary by evangelical scholar Victor P. Hamilton takes the position that the “days” of Genesis 1 must be taken as non-figurative and nonmetaphorical, that is, as literal, consisting of solar days of 24 hours.<sup>39</sup> However, as a broad concordist he is already committed to long ages and remains interested in bringing about a harmony with modern naturalistic science. In order to do so he appeals to “a literary reading of Gen. 1 [which] still permits the retention of ‘day’ as a solar day of 24 hours.”<sup>40</sup> How is this accomplished?

Hamilton speaks of a “literary reading” of the Genesis creation account. The “literary reading” allows him to understand the “days” of creation literally but “not as a chronological account of how many hours God invested in His creating project, but as an analogy of God’s creative activity.”<sup>41</sup> In this view the 24-hour “days” in Genesis 1 are but an “analogy” based on a “literary [non-historical] reading” of the Genesis creation account.

This view of a “literary reading” is dependent on Charles E. Hummel.<sup>42</sup> Hummel argues that even if the “days” in Genesis 1 are to be meant as solar days of 24 hours, which he believes they are, “the question still remains whether the [literary] format is figurative or literal, that is, *analogy* of God’s creative activity or a chronological *account* of how many hours he worked.”<sup>43</sup> Hummel believes that the “who” and “why” but not the “how” of creation is important (following Bernard

Ramm) and that, therefore, the “*analogy* ... provides a model for human work.”<sup>44</sup>

The “analogy” theory consists of the understanding of the literal “day” as “a metaphor” which uses “the commonplace (or commonly understood, if you wish) meaning of a word” (viz. the word “day”) “in a figurative manner.”<sup>45</sup> The analogy transfer suggested by the “analogy” theory removes the schema of six days of work and one day of rest from a chronological piece of information and makes it into a broad pattern of work-and-rest applicable to humanity.<sup>46</sup>

As appealing as this “analogy” theory seems to be, the issue is still the problem of the contextual and literary warrant within the context of Genesis 1 and the Bible as a whole for taking the time designation “day” as simply analogous for work/rest. Hummel is forced (followed by Hamilton) to redefine the literary genre of Genesis 1 from that of a straightforward creation account to a genre which is designated as a “semipoetic narrative”<sup>47</sup> which has significance. This falls under the “*historical-cultural*” approach to creation.<sup>48</sup>

It is evident that these broad concordist scholars are partially influenced by form-criticism and its genre method of interpretation. Form-criticism, a sub-method of the historical-critical method, was begun by Hermann Gunkel, known as the father of form criticism, at the turn of the century.<sup>49</sup> Gunkel raised the question, “Are the narratives of Genesis history or legend?”<sup>50</sup> His premise is that “many things reported in Genesis ... go directly against our better knowledge.”<sup>51</sup> The idea of “our better knowledge” is an admission on Gunkel’s part that a naturalistic evolutionary world view provides the authoritative norm of what is history or legend. Thus, he suggested that the literary genre of Genesis is not history but “legend.” Gunkel was the first liberal scholar to assign to the creation account in Genesis a literary genre other than history in the sense of a factual account. He has been followed by other liberal scholars, by neo-orthodox theologians, and now also in part by neoevangelical scholars who are broad concordists.

Although we need not attempt to be exhaustive in citing the literary genre categories which have been proposed for categorizing Genesis, some major representative examples should be cited. Karl Barth, the father of neo-orthodox theology, takes Genesis 1-2 as “saga”<sup>52</sup> and, of course, non-historical. S.H. Hooke, the leader of the myth-and-ritual school, says that the Genesis creation account is a “cultic liturgy.”<sup>53</sup> Gordon Wenham, a neo-evangelical scholar, believes it to be a “hymn.”<sup>54</sup>

Walter Brueggemann, a liberal non-concordist, suggests that it is a “poem.”<sup>55</sup> Claus Westermann, a form-critic, calls it a “narrative.”<sup>56</sup> John H. Stek, a broad concordist, names it a “metaphorical narration.”<sup>57</sup> Gerhard von Rad, a tradition critic, designates it as “doctrine.”<sup>58</sup> Others hold that it is a “myth,”<sup>59</sup> “parable,”<sup>60</sup> “story,” “theology,”<sup>61</sup> “allegory,” etc.

There are several essential observations to be made in view of this plethora of current opinions on the nature of the literary genre of the Genesis creation account.

- 1) The obvious consensus is that there is no consensus on the literary genre of Genesis 1. This makes the literary genre approach for a non-literary reading of Genesis 1 suspect of special pleading.

Since there is no consensus, the careful interpreter will be rather cautious and avoid jumping on the bandwagon of literary genre identification with the aim to redefine the literal intent of Genesis 1. The intention of form-critical genre description from its beginning, the time of Gunkel to the present, has been to remove the text of Genesis 1 from being considered to be historical and factual in nature.<sup>62</sup>

- 2) The “literary genre” approach reveals it to be another way, at first used by non-concordists, to remove the creation account of Genesis from functioning as an authoritative, literal text which has implications for the relationship of science and the Bible. It is rightly suggested that “the way in which God revealed the history of creation must itself be justified by Scripture”<sup>63</sup> and not by appeal to form-critical literary genre description from which historicity is removed.
- 3) Interpreters following the “literary genre” approach with the aim to remove the creation account from the realm of its literal intent feel free to interpret the “days” of creation in a literal and grammatical way.

The use of the “literary genre” approach is meant to restrict the meaning of Genesis 1 to a thought-form which does not demand a factual, historical reading of what took place. The “literary genre” redefinition of the creation account is intended to remove the creation account from informing modern readers on “how” and “in what manner” and in what time God created the world. It simply wishes to affirm minimalistically

that God is Creator. And that affirmation is meant to be a theological, nonscientific statement which has no impact on how the world and universe came into being and developed subsequently.

The “literary genre” approach is based on a literary critical methodology,<sup>64</sup> which is intended to assign to the creation account as a whole a function different from that of historicity or factuality. In this case it does not matter whether the creation “days” are taken as literal 24-hour days in its intent, because the account as a whole, including the creation “days,” has a meaning other than a historical or factual one.

## **2. Genesis 1: Literal or Figurative?**

The question remains whether the creation account of Genesis 1 is literal or figurative as a whole.<sup>65</sup> Often Genesis 1 is taken together as part of the larger unit of Genesis 1–11 to answer the question of its nature, purpose and function.

It is an acknowledged fact that these chapters at the beginning of the book of Genesis have singularities, that is, unrepeated, one-time events, that have no immediate analogy in present experience.

How does the modern historian handle such singularities? The standard position of modern historiography is based on the principle of analogy (cf. Ernst Troeltsch), that is, the principle that nothing in past experience can be reckoned to be historical except as it corresponds to present experience.<sup>66</sup> This principle is based on the notion of the basic uniformity of human experience and historical events.<sup>67</sup> The principle of analogy holds that the past is understood only by borrowing from the present and applying it to the past.

Based on the consistent application of this uniformitarian basic to the principle of analogy, there is cause to deny the historicity and facticity of most of Genesis 1-11, including the creation account of Genesis 1. Can and should the uniformitarian principle of analogy reign as the supreme norm for understanding the past?<sup>68</sup> “A problem arises when the uniformity [of past and present] is raised to a universal principle that makes some evidence inadmissible,” writes a strong supporter of the principle of analogy and modernistic historiography.<sup>69</sup> This admission of the problem requires great caution in the application of the uniformitarian principle of analogy.

Human beings know of experiences in present reality that are singular and without parallel in the past. For example, twenty-five years ago the first human beings were walking on the moon. This had never



happened before. Another example is the use of atomic bombs for the destruction of two Japanese cities in 1945. This type of destruction has never happened before and stands unique to the present. Many other singularities could be mentioned.

As there are singularities today that are either man-made or part of another order, that is to say, there are real events and situations that have no analogy in the past, so one can recite singularities in the past which have no analogy at present. For example, R. G. Collingwood, the famed British philosopher of history, noted that the ancient Romans engaged in population control by exposing newborn infants to die. This is a singularity which has no analogy at present in population control attempts.<sup>70</sup>

With these limitations of the principle of analogy in mind,<sup>71</sup> it is not sound to reject the creation account as non-historical and non-factual because we know of no analogy at present. Genesis 1 contains singularities that may be perceived to be just as real, historical and factual as the singularities of another kind in the present or the past.

There are good reasons for maintaining that Genesis 1 is a factual account of the origin of the livable world. This record is accurate, authentic and historical.

### **3. Genesis 1 and Comparative Literature of the Past**

From a purely comparative approach of the literary structures, the language patterns, the syntax, the linguistic phenomena, the terminology, the sequential presentation of events in the creation account, Genesis 1 is not different from the rest of the book of Genesis<sup>72</sup> or the Pentateuch for that matter.

Compared to the hymns in the Bible, the creation account is not a hymn; compared to the parables in the Bible, the creation account is not a parable; compared to the poetry in the Bible, the creation account is not a poem; compared to cultic liturgy, the creation account is not a cultic liturgy. Compared to various kinds of literary forms, the creation account is not a metaphor, a story, a parable, poetry, or the like.

One recent study of the literary form of Genesis 1-11 done on the basis of current comparative Near Eastern literature has concluded that “we are dealing with the genera of historical narrative-prose, interspersed with some lists, sources, sayings, and poetical lines.”<sup>73</sup> This is a fairly good description of the content of Genesis 1.

A detailed study of the literary form of Genesis 1 has concluded that we are dealing with the literary genre of “prose-genealogy.”<sup>74</sup> Even Gunkel noted long ago that Genesis is “prose.” He noted also that it is “more artistic in its composition and has some sort of rhythmical construction.”<sup>75</sup> The non-poetic nature of Genesis 1 shows that its intention is to take it in its plain sense as a straightforward and accurate record of creative events.

Looking at the information provided in Genesis 1 from a perspective of comparison with other ancient Near Eastern literature, it must be concluded that “Genesis 1 has no parallel anywhere in the ancient world outside the Bible.”<sup>76</sup> Genesis 1 is the most cohesive and profound record produced in the ancient world of “how” and “when” and by “whom” and “in what manner” the world was made. There is no parallel to it from the ancient world in any type of literature. There are bits and pieces which have been compared from various cosmogonic myths and speculations, but the biblical creation account as a unit stands unique in the ancient world in its comprehensiveness and cohesiveness.<sup>77</sup>

#### **4. The Literary Form of Genesis 1 Within Its Biblical Context**

It would be helpful to analyze the literary form in distinction to the “literary genre” of form criticism discussed above.

John H. Stek suggests that the “literary type [of Genesis 1], as far as present knowledge goes, is without strict parallel; it is *sui generis*.”<sup>78</sup> It has already been noted that the presentation and content of Genesis 1 as a whole is unparalleled in the ancient world.<sup>79</sup> Does this mean, however, that it is *sui generis* in the sense that it should not be understood to be literal in its intention? Surely as creation itself is unique so the creation account is of necessity unique. But it is hardly *sui generis* in an exclusive literary sense which will remove it from communication on a factual, accurate and historical level.

Based on the relationship with the remainder of Genesis (and the Bible as a whole), the creation account (Genesis 1:1 – 2:3), can be properly designated in its literary form. The creation account of Genesis 1 is a historical prose-record, written in rhythmic style, recording factually and accurately “what” took place in the creation of “the heavens and the earth,” depicting the time “when” it took place, describing the processes of “how” it was done and identifying the divine Being “who” brought it forth. The result of creation week was a perfect, “very good” world with an environment suited to the utmost for created humanity to

live in. This historical prose-record of creation reports correctly in specific sequences the creation events within chronological, sequential, and literal “days.” These “days” inaugurate the subsequent historical process of time ordered in weekly cycles in which man and nature function under God’s ultimate control. In this sense Genesis 1 is the inaugural history<sup>80</sup> of initial beginnings which shapes from creation week onward the following flow of the history of the world and humanity.

## V. LITERAL INTERPRETATION OF CREATION “DAYS”

We shall consider the usage of “day” (Hebrew *yôm*) along major lines of current scholarship. There are liberal and non-liberal scholars who have concluded that the word “day” (Hebrew *yôm*) in Genesis 1 must be singularly understood in a literal sense. We will review some of their reasons and provide additional ones.

### 1. Considerations from Commentaries

The influential Continental liberal Old Testament theologian and exegete Gerhard von Rad states, “The seven days are unquestionably to be understood as actual days and as a unique, unrepeatable lapse of time in the world.”<sup>81</sup> Gordon Wenham, a British non-concordist Old Testament scholar, concludes, “There can be little doubt that here ‘day’ has its basic sense of a 24-hour period.”<sup>82</sup> James Barr, renowned Semitist and Old Testament scholar, notes with vengeance against figurative interpreters that the creation “days” were six literal days of a 144-hour period.<sup>83</sup> Form critic Hermann Gunkel concluded long ago, “The ‘days’ are of course days and nothing else.”<sup>84</sup> This refrain can be continued with many additional voices, sharing the same non-concordist position.

Victor P. Hamilton concludes, as do other broad concordist neoevangelical scholars, “And whoever wrote Gen. 1 believed he was talking about literal days.”<sup>85</sup> John H. Stek, another broad concordist, makes a number of points in his support for literal “days”:

*Surely there is no sign or hint within the narrative [of Genesis 1] itself that the author thought his ‘days’ to be irregular designations — first a series of undefined periods, then a series of solar days — or that the ‘days’ he bounded with ‘evening and morning’ could possibly be understood as long aeons of time. His language is plain and simple, and he speaks in plain and simple terms of one of the most common elements in humanity’s experience of the world... In his storying of God’s creative acts, the author was ‘moved’*

*to sequence them after the manner of human acts and 'time' them after the pattern of created time in humanity's arena of experience.*<sup>86</sup>

Numerous scholars and commentators, regardless of whether they are concordist or non-concordist, have concluded that the creation “days” cannot be anything but literal 24-hour days. They are fully aware of the figurative, non-literal interpretations of the word “day” in Genesis 1 for the sake of harmonization with the long ages demanded by the evolutionary model of origins. Yet, they insist on the ground of careful investigations of the usage of “day” in Genesis 1 and elsewhere that the true meaning and intention of a creation “day” is a literal day of 24 hours.

## **2. Considerations from Lexicography**

The most widely recognized Hebrew lexicons and dictionaries of the Hebrew language published in the twentieth century affirm that the designation “day” in Genesis 1 is meant to communicate a 24-hour day, respectively, a solar day.

A prestigious recently published lexicon refers to Genesis 1:5 as the first scriptural entry for the definition of “day of 24 hours” for the Hebrew term *yôm* (“day”).<sup>87</sup> Holladay’s Hebrew-English lexicon follows suit with “day of 24 hours.”<sup>88</sup> The Brown-Driver-Briggs lexicon, the classical Hebrew-English lexicon, also defines the creation “day” of Genesis 1 as a regular “day as defined by evening and morning.”<sup>89</sup>

Lexicographers of the Hebrew languages are among the most qualified of Hebrew scholars. They are expected to give great care in their definitions and also usually indicate alternative meanings, if there is warrant to do so in given instances. None of the lexicographers have departed from the meaning of the word “day” as a literal day of 24 hours for Genesis 1.

## **3. Considerations from Dictionaries**

Magne Saeboe writes in the acclaimed *Theological Dictionary of the Old Testament* that the “day” (*yôm*) in Genesis 1 has a literal meaning in the sense of “a full day.”<sup>90</sup> He does not entertain another meaning or alternative.

Ernst Jenni, an acclaimed Hebrew scholar of the twentieth century, states in the most-widely used theological dictionary of the Hebrew language that the meaning of “day” in the Genesis creation account is to be understood in its literal meaning as a “day of 24 hours in the sense of an astronomical or calendrical unit of time.”<sup>91</sup>

#### 4. Considerations Based on Semantics

The field of semantics in linguistic study refers to what is called signification.<sup>92</sup> It deals with the issue of “the accurate evaluation of the meaning of expressions [words, phrases, clauses, sentences, etc.] which have actually been used.”<sup>93</sup>

Semantics calls for attention to the crucial question of the exact meaning of the Hebrew word *yôm*. Could the designation “day” in Genesis 1 possibly have a figurative meaning in this chapter? Is it to be understood on the basis of the norms of semantics as a literal “day”? This matter of semantics is particularly important in view of the fact that the Hebrew term *yôm* in the singular and plural has a large variety of meanings, including extended meanings such as “time,” “life time,” and so on. Is it possible to import an extended meaning from the Old Testament into Genesis 1? Could this not solve the problem of the conflict of a short creation week and the long ages called for by naturalistic evolution?

The Hebrew term *yôm*, in its variety of forms, can mean aside from a literal “day” also a time or period of time (Judges 14:4) and in a more general sense “a month [of] time” (Genesis 29:14), “two years [of] time” (2 Samuel 13:23; 14:28; Jeremiah 28:3, 11), “three weeks [of] time” (Daniel 11:2, 3). In the plural form it can mean “year” (1 Samuel 27:7), a “life time” (Genesis 47:8), and so forth. Any good lexicon will provide a comprehensive listing of the various possibilities.<sup>94</sup>

It is important to keep in mind that “the semantic content of the words can be seen more clearly in their various combinations with other words and their extended semantic field.”<sup>95</sup>

What are the semantic-syntactical guidelines for extended, non-literal meanings of the Hebrew term *yôm*? The extended, non-literal meanings of the term *yôm* are always found in connection with prepositions,<sup>96</sup> prepositional phrases with a verb, compound constructions, formulas, technical expressions, genitive combinations, construct phrases, and the like.<sup>97</sup> In other words, extended, non-literal meanings of this Hebrew term have special linguistic and contextual connections which indicate clearly that a non-literal meaning is intended. If such special linguistic connections are absent, the term *yôm* does not have an extended, non-literal meaning; it has its normal meaning of a literal day of 24-hours.

In view of the wealth of usages of this Hebrew term, it is imperative to study the usage of the term *yôm* in Genesis 1 so that it can be compared

with other usages. Does this chapter contain the needed indicators by which *yôm* can clearly be recognized to have a literal or non-literal meaning? How is this term used in Genesis 1? Is it used together with combinations of other words, prepositions, genitive relations, construct state, and the like, as mentioned in the previous paragraph, which would indicate a non-literal meaning? It is exactly these kinds of semantic-syntactical combinations which inform us about the intention of the meaning of this term.

Let us present the facts of the usage of the term *yôm*, “day,” in Genesis 1 as any scholar who knows Hebrew can describe them:

1. The term *yôm* is always used in the singular.
2. The term *yôm* is always joined to a numeral. In Genesis 1:5 it is a cardinal and elsewhere in Genesis 1:1 – 2:3 it is always an ordinal. We will pay attention to this below.
3. The term *yôm* is never combined with a preposition, genitive combination, construct state, compound construction, or the like. It always appears as a plain noun.
4. The term *yôm* is consistently defined by a temporal phrase in the preceding sentence, “and there was evening and there was morning.” This clause serves in a defining function for the word “day.”
5. The complementary creation account of Genesis 2:4-25 contains a non-literal, figurative meaning of the singular of the term *yôm*, “day.” When the non-literal meaning is intended the semantic-syntactical conventions known from the remainder of the Old Testament for such a meaning are employed. This is the case in the non-literal usage in Genesis 2:4.

Let us note these criteria as they are employed in Genesis 2:4. The noun *yôm* is joined to the preposition *be* to read *beyôm*. Secondly, it is used in a construct relation with the infinitive form of *ʿasah*, “to make.” It reads literally, “in the day of making.” This combination of the singular with a preposition in construct with an infinitive<sup>98</sup> makes this combination a “temporal conjunction,”<sup>99</sup> which serves as a “general introduction of time.”<sup>100</sup>

Genesis 2:4b reads literally, “in [the] day of the Lord God making the earth and heaven.” Proper English calls for the literal “in [the] day of,” which is syntactically a temporal conjunction that serves as a general

introduction of time, to be rendered with “when.” This sentence then reads, “When the Lord God made ....” This clear-cut case of an extended, non-literal use of *yôm* in the creation account of Genesis 2:4-25 shows that the contrary usage of *yôm* in Genesis 1, without any expected qualifier that marks it as a non-literal use, has a literal meaning. The term *yôm* in Genesis 1 has no prepositions; it is not used in a construct relation and it has no syntactical indicator expected of an extended, non-literal meaning. Thus, in Genesis 1 *yôm* can mean only a literal “day” of 24 hours.

In short, the semantic-syntactical usages of *yôm*, “day,” in Genesis 1 as compared with semantic-syntactical usages and linguistic connections of this term in other Old Testament passages where it has an extended meaning, does not allow it to mean a long period of time, an age, or the like. The Hebrew language, its grammar, syntax, linguistic structures as well as its semantic usage allows for only the literal meaning of “day” for the creation “days” of Genesis 1.

## 5. Considerations Based on Singular Usage

The Hebrew term *yôm* appears in the Hebrew Old Testament 2,304 times<sup>101</sup> of which 1,452 usages are in the singular.<sup>102</sup>

In the Five Books of Moses (Pentateuch) this term is used 668 times and in the book of Genesis it is employed 152 times.<sup>103</sup> In Genesis the singular usage of “day” appears 83 times, the remainder usages are in the plural.

In the enumeration of the six “days” of creation the term “day” is used consistently in the singular. There is one plural use in the phrase “for days and years” in vs.14 which is, of course, not a creation “day.” This plural usage in vs.14 hardly enters the discussion of making creation “days” long periods of time since calendrical usage of “days and years” keeps it literal itself. There is no doubt but that the literal meaning of 24-hour days are meant in vs.14 just as the “years” are likewise understood as literal years.

The additional usages of “day” in the singular in Genesis 1 are found in vss.5 and 16. “And God called the light ‘day’ (*yôm*)” (vs.5) and God made the “greater light to govern the day” (vs.16). The term in vs.5 is employed in the sense of the literal daylight period of the light part of the 24-hour period of time in contrast to the night part, “the night” (vs. 16), of the same period of time.<sup>104</sup> Both “day” and “night” make a “full day.”<sup>105</sup>

We have to recognize the fact that the term *yôm* in every one of the six days has the same connection: a) It is used as a singular; b) it has a numeral; and c) it is preceded by the phrase, “there was evening and there was morning.” This triple interlocking connection of singular usage, joined by a numeral, and the temporal definition of “evening and morning,” keeps the creation “day” the same throughout the creation account. It also reveals that “time is conceived as linear and events occur within it successively.”<sup>106</sup> To depart from the numerical, consecutive linkage and the “evening-morning” boundaries in such direct language would mean to take extreme liberty with the plain and direct meaning of the Hebrew language.<sup>107</sup>

## 6. Considerations Based on Numeral Usage

The six creation “days” are in each instance joined with a numeral in the sequence of one to six (Genesis 1:5,8,13,19,23,31). The day following the “sixth day,” the “day” on which God rested, is designated “the seventh day” (Genesis 2:2 [2 times],3).

What seems of significance is the sequential emphasis of the numerals 1-7 without any break or temporal interruption. This seven-day schema, the schema of the week of six workdays followed by “the seventh day” as rest day, interlinks the creation “days” as normal days in a consecutive and non-interrupted sequence.

When the word *yôm*, “day,” is employed together with a numeral, which happens 150 times in the Old Testament, it refers in the Old Testament invariably to a literal day of 24 hours.

This rule is pervasive in the Old Testament. The only exception in numbers of 1-1,000 is found in an eschatological text in Zechariah 14:7. The Hebrew expression *yôm 'echad* employed in Zechariah 14:7 is rendered into English in a variety of ways: “for it will be a unique day” (New American Standard Bible, New International Version); “and there shall be continuous day” (New Revised Standard Version); “it will be continuous day” (Revised English Bible); or “and the day shall be one.”<sup>108</sup> The “continuous day,” or “one day,” of the eschatological future will be one in which the normal rhythm of evening and morning, day and night, as it is known will be changed so that in that eschatological day there shall be “light even at the evening” (vs.7). It is generally acknowledged that this is a difficult text in the Hebrew language and can hardly be used to change the plain usage in Genesis 1.<sup>109</sup>



## 7. Considerations Based on Article Usage

The term “day” is used in Hebrew without the article in each instance of each creation day, except in the cases of “the sixth day” (Genesis 1:31, Hebrew *yôm hashshishî*) and “the seventh day” (Genesis 2:2).<sup>110</sup>

It is noted from time to time that the first “day” of Genesis 1:5 in Hebrew reads literally “one day,”<sup>111</sup> because we have the cardinal number “one” used with the term “day.”

The lack of the definite article has been interpreted to mean that all creation “days” (except “the sixth day,” which has the article) will allow “for the possibility of random or literary order as well as a rigidly chronological order.”<sup>112</sup> This is a rather shaky interpretation. It cannot be supported from semantic-syntactical points of view.

We need to understand the syntax of the Hebrew text and interpret the text accordingly without violence to the internal structure of the Hebrew language. The recent research grammar by Bruce K. Waltke and M. O’Connor points out that the indefinite noun *yôm* with the indefinite cardinal numeral for “one” (Hebrew *’echad*) in Genesis 1:5 has “an emphatic, counting force” and a “definite sense” in addition to having the force of an ordinal number which is to be rendered as “the first day.”<sup>113</sup>

Based on this syntactical observation of the Hebrew language, “the first day” and “the sixth day” of the creation week are meant to be definite in the sense that they have the article by syntactical rule or by writing (not to speak of “the seventh day” which will be considered below). The first and last creation “days” are definite by syntax or writing, the first by syntactical function and the last by the usage of the article. One observation emerges — this definite usage of the first and last day of creation forms a literary device, an *inclusio*, which frames the six creation “days” with definite or articular days. One of the intentions of this usage seems to be that the “days” of Genesis 1 do not permit the conclusion that random order or chronological order is an open-ended issue.<sup>114</sup>

The opposite is actually the case. Since the first and sixth days are definite, providing a clear boundary, the days are meant to be chronological and sequential, forming an uninterrupted six-day period of literal 24-hour days of creation. Thus, the definite use of the first and sixth days respectively mark and frame the six-day sequence into a coherent

sequential and chronological unit of time which will be repeated in each successive week.

“The seventh day” is also written with the Hebrew article. Since “the first day” (vs. 5) is definite as well as “the sixth day” (vs. 31), a larger unit is formed. It is the unit of six workdays followed by “the seventh day” (Genesis 2:2,3), the day of rest. In this way the sequence of six workdays find their goal and climax chronologically and sequentially in “the seventh day,” making together the weekly cycle with the day of rest being the “seventh day” of the week.

The larger unit of literal time accordingly consists of the divinely planned unit of the “six-plus-one schema” which consists of the “six” workdays followed in an uninterrupted manner and in sequence by “the seventh day” of rest. This uninterrupted sequence is divinely planned and ordained as the rhythm of the time for each successive week.

### **8. Considerations Based on the “Evening-Morning” Boundary**

The Genesis creation account not only links each day to a sequential numeral but it also sets the time boundaries by “evening and morning” (vss.5,8,13,19,23,31). The rhythmic boundary phrase, “and there was evening and there was morning,” provides a definition of the creation “day.” The creation “day” is defined as consisting of “evening” and “morning.” It is a literal “day.”

The term for “evening” (Hebrew *'ereb*)<sup>115</sup> covers the dark part of the day in a *pars pro toto* (meaning that a part, in this case the “evening,” stands for the whole dark part of the day) usage (cf. “day-night” in Genesis 1:14). The corresponding term “morning” (Hebrew *bqer*) stands *pars pro toto* (meaning that a part, in this case the “morning,” stands for the light part of the day) “for the entire period of daylight.”<sup>116</sup> It is to be noted that the “evening-morning” expression must be understood to have the same signification in every one of its six usages.<sup>117</sup>

“Evening and morning” is a temporal expression which defines each “day” of creation as a literal day. It cannot be made to mean anything else.

### **9. Considerations Based on Pentateuchal Sabbath Passages**

Another kind of internal evidence provided in the Old Testament for the meaning of days derives from two Sabbath passages in the Pentateuch which refer back to the creation “days.” They inform the reader how the creation “days” were understood by God.

The first passage is part of the Fourth Commandment spoken by God on Mt. Sinai and recorded recorded in Exodus 20:9-11: “Six days you shall do all your labor ... but the seventh day is the sabbath of the Lord your God.... For in six days the Lord made the heavens and the earth ... and rested on the seventh day; therefore the Lord blessed the sabbath day and made it holy.”

“These words” are spoken by Yahweh Himself (vs. 1). The linkages to creation are in wording (“seventh day,” “heaven and earth,” “rested,” “blessed,” “made it holy”) and in the “six-plus-one” schema (see also Deuteronomy 5:13-14) to mention but these.<sup>118</sup> Evidently the words used in the Ten Commandments take the creation “day” as “a regular day”<sup>119</sup> of 24 hours and demonstrate that the weekly cycle is a temporal creation ordinance.

These words of the Lord provide an internal Pentateuch and Old Testament guideline on how God, the Giver of the “Ten Words” understands the creation “day.” The divine speech which promulgates the Sabbath commandment takes the “six days” of creation to be sequential, chronological and literal.<sup>120</sup>

The argument that the relationship of the Fourth Commandment is but an “analogy” or “archetype” in the sense that man’s rest on the seventh day ought to be like God’s rest in creation<sup>121</sup> is based on reductionism and an impermissible change of imagery. Terence Fretheim noted incisively that the Commandment does not use analogy or archetypal thinking but that its emphasis is “stated in terms of the imitation of God or a divine precedent that is to be followed: God worked for six days and rested on the seventh, and therefore you should do the same.”<sup>122</sup>

The second Pentateuchal Sabbath passage is Exodus 31:15-17, which is again spoken by God Himself. It has several terminological linkages with Genesis 1 and is conceptually and thematically related to it. This passage has to be understood to mean that the creation “day” was a literal day and that the days were sequential and chronological. The weekly sabbath for God’s people is based on imitation and example, for “in six days the Lord made heaven and earth, but on the seventh day he ceased from labor, and was refreshed” (vs. 17, New American Standard Bible).

God was refreshed because He had delight in His completed work of creation. Humankind will also be refreshed and have delight when the Sabbath as “seventh day” (vs. 15) is kept.

The “sign” nature of the Sabbath in vs. 15 reveals that the Sabbath keeper follows the divine Exemplar. He Himself kept “the seventh day” which humans who belong to Him will imitate. They will do so in the same rhythm of the literal weekly cycle of six literal workdays followed chronologically and sequentially by “the seventh day” as a day of rest and refreshment as their Creator had done during creation week.

### **10. Considerations Based on Sequence of Events**

The creation of vegetation with seed-bearing plants and fruit trees took place on the third day (Genesis 1:11-12). Much of this vegetation seems to need insects for pollination. Insects were created on the fifth day (vs. 20). If the survival of those types of plants which needed insects for pollination depended on them to generate seeds and to perpetuate themselves, then there would be a serious problem should the creation “day” consist of long ages or aeons. The type of plant life dependent on this type of pollination process without the presence of insects could not have survived for these long periods of time, if “day” were to mean “age” or “aeon.” In addition, “consistency of interpretation in the ‘day-age theory’ would demand a long period of light and darkness during each of the ages. This would quickly be fatal both to plant and animal life.”<sup>123</sup>

It seems that the creation “day” is expected to be understood as a literal day and not as a long period of time whether ages, periods, or aeons.

Although these arguments may not be decisive, they nevertheless point in the same direction as the decisive linguistic and semantic points which are found in the Hebrew text itself.

## **VI. CONCLUSIONS**

This paper investigated the meaning of creation “days.” It has considered key arguments in favor of a figurative, non-literal meaning of the creation “days.” It found them to be wanting on the basis of genre investigation, literary considerations, grammatical study, syntactical usages, and semantic connections. The cumulative evidence, based on comparative, literary, linguistic and other considerations, converges on every level, leading to the singular conclusion that the designation *yôm*, “day,” in Genesis 1 means consistently a literal 24-hour day.

The author of Genesis 1 could not have produced more comprehensive and all-inclusive ways to express the idea of a literal “day” than

the ones that were chosen. There is a complete lack of indicators from prepositions, qualifying expressions, construct phrases, semantic-syntactical connections, and so on, on the basis of which the designation “day” in the creation week could be taken to be anything different than a regular 24-hour day. The combinations of the factors of articular usage, singular gender, semantic-syntactical constructions, time boundaries, and so on, corroborated by the divine promulgations in such Pentateuchal passages as Exodus 20:8-11 and Exodus 31:12-17, suggest uniquely and consistently that the creation “day” is meant to be literal, sequential, and chronological in nature.

## ENDNOTES

1. The designation “creation-science” has been defined by Louisiana law (Senate Bill No. 86, 1981) as follows: “‘Creation-science’ means the scientific evidences for creation and inferences from those scientific evidences.” A similar wording was used shortly before in the Arkansas Bill (Act 590) of March 19, 1981. For details, see: Norman L. Geisler, *The Creator in the Courtroom* (Milford, MI: Mott Media, 1982), 5, 224. Phillip E. Johnson states that “‘creation science’ refers to young-earth, six-day special creation” (*Darwin on Trial*, 2d ed. [Downers Grove, IL: InterVarsity Press, 1993], 4 n 1).
2. This designation is preferred and argued for by Norman L. Geisler and J. Kerby Anderson, *Origin Science: A Proposal for the Creation-Evolution Controversy* (Grand Rapids, MI: Baker Book House, 1987).
3. The significant volume of essays edited by J.P. Moreland (1994. *The Creation Hypothesis: Scientific Evidence for an Intelligent Designer*. [Downers Grove, IL: InterVarsity Press, 1994]) uses the designation “theistic science” as opposed to “naturalistic science,” the common notion of science which rules out the God-hypothesis from the start. “Theistic science” is a “research program ... that, among other things, is based on two propositions: 1. God, conceived of as a personal, transcendent agent of great power and intelligence, has through direct, primary causation and indirect secondary causation created and designed the world for a purpose and has directly intervened in the course of its development at various times.... 2. The commitment expressed in proposition 1 can appropriately enter into the very fabric of the practice of science and the utilization of scientific methodology” (p 41-42). This definition is elaborated in the remainder of the seminal essay by J.P. Moreland in the above volume (“Theistic Science & Methodological Naturalism,” p 41-66).
4. Frederic W. Farrar, *History of Interpretation* (1866; reprint, Grand Rapids, MI: Baker Book House, 1961), 187-203.
5. The decisive section from Origen’s *On First Principles: Book Four* (excerpt quoted in Karlfried Froehlich K (trans./ed), *Biblical Interpretation in the Early Church*. [Philadelphia: Fortress Press, 1984], 63) noted that the days of creation cannot be understood to be literal just as it “is foolish enough to believe that, like a human farmer, God planted a garden to the east of Eden and created in it a visible, physical tree of life....” See also Terence E. Fretheim, “Were the Days of Creation Twenty-Four Hours Long?” in *The Genesis Debate: Persistent Questions About Creation and the Flood*, ed. Ronald R. Youngblood (Nashville, TN: Thomas Nelson, 1986) 12-35.
6. Augustine, *The City of God* XI, iv, vi-vii.

7. The fourfold sense of Scripture consists of the following: 1) the literal sense, 2) the allegorical (spiritual-mystical) sense; 3) the anagogical (future) sense, and 4) the tropological (moral) sense. See Farrar, 205.
8. The new *Catechism of the Catholic Church*, published in English in 1994, states: "According to an ancient tradition, one can distinguish between two senses of Scripture: the literal and the spiritual, the latter being subdivided into the allegorical, moral [tropological], and anagogical senses. The profound concordance of the four senses guarantees all its richness to the living reading of Scripture in the Church." Later on the same page it is affirmed: "It is the task of exegetes to work, according to these rules, toward a better understanding and explanation of the meaning of Sacred Scripture..." (*Catechism of the Catholic Church* [Vatican City: Libreria Editrice Vaticana, 1994], 33).
9. See: (a) Robert M. Grant, *A Short History of the Interpretation of the Bible* (NY: Macmillan, 1963), 128-129; (b) Emil G. Kraeling, *The Old Testament Since the Reformation* (NY: Schocken Books, 1969), 9-32; (c) John Rogerson, Christopher Rowland, and Barnabas Lindars, *The Study and Use of the Bible*, vol.2 of *The History of Christian Theology* (Grand Rapids, MI: Wm. B. Eerdmans Publishing Co., 1988), 77-95.
10. Martin Luther, *Lectures on Genesis: Chapters 1-5, Luther's Works* (St. Louis, MO: Concordia Publishing House, 1958), 1:5. Later, Luther in commenting on the phrase "evening and morning" states that the creation day "consists of twenty-four hours" (1:42).
11. The development of the historical-critical method from the late seventeenth century onward until its full maturity at the end of the nineteenth century did not decisively change the interpretation of the creation "days." The reason for this is that the biblical text was now seen as an artifact of the past which has no direct relationship to the belief systems of the present.
12. The Scottish theologian Thomas Chalmers (1780-1847) is credited with being the first proponent of the view that the six creation "days" are actually "days of reconstruction," giving rise to the "ruin-reconstruction hypothesis" (see W. Hanna, ed., *Select Works of Thomas Chalmers* [Edinburgh: T. Constable and Co., 1855], 5: 146-150). This hypothesis has found strong defenders such as George H. Pember (*Earth's Earliest Ages*, 2d ed. [London: Hodder and Stoughton, 1907]) and more recently A. C. Cuxance, *Without Form and Void* (Brookville, Ont: By the Author, 1970). The most detailed and scholarly critique of the "ruin-reconstruction hypothesis" has been produced by Weston W. Fields, *Unformed and Unfilled: The Gap Theory* (Phillipsburg, NJ: Presbyterian and Reformed Publishing Co., 1978). See also, Henn Blocher, *In the Beginning: The Opening Chapters of Genesis* (Downers Grove, IL: InterVarsity Press, 1984), 41-43.
13. While not the first to claim that the days of creation are actually six days of revelation, and not days of creation, the Scottish geologist Hugh Miller (1802-1856) was the foremost nineteenth-century author to proclaim this idea (Francis Haber, *The Age of the World: Moses to Darwin* [Baltimore, MD: The Johns Hopkins University Press, 1959], 236-237). In this century this view was propounded by R.J. Wiseman, the father of the famous Assyriologist Donald Wiseman. More on this later.
14. The "day-age" theory originated in the eighteenth century and came to prominence in the nineteenth century through the writings of geologists James D. Dana and J.W. Dawson. See (a) Bernard Ramm, *The Christian View of Science and Scripture*, 2d ed. (Grand Rapids, MI: Wm. B. Eerdmans Publishing Co., 1971), 211; and (b) Haber, 122-123, 199-200, 255.

15. For a review of these ideas, see Thomas A. McIver, "Creationism: Intellectual Origins, Cultural Context and Theoretical Diversity" (Ph.D. diss., University of California, Los Angeles, 1989), 450-495.
16. Among the many studies that have gone into this, see (a) Charles Coulston Gillispie, *Genesis and Geology: A Study in the Relations of Scientific Thought, Natural Theology and Social Opinion in Great Britain, 1790-1850* (NY: Harper Torchbooks, 1959); (b) R. Hooykaas, *Religion and the Rise of Modern Science* (Grand Rapids, MI: Wm. B. Eerdmans Publishing Co., 1972).
17. Some illuminating recent publications on this shift include (a) Richard J. Blackwell, *Galileo, Bellarmine, and the Bible* (Notre Dame, IN: University of Notre Dame Press, 1991); (b) Charles E. Hummel, *The Galileo Connection: Resolving Conflicts between Science and the Bible* (Downers Grove, IL: InterVarsity Press, 1986); (c) William John Hausmann, *Science and the Bible in Lutheran Theology* (Washington, DC: University Press of America, 1978).
18. Vern S. Poythress, *Science and Hermeneutics: Implications of Scientific Method for Biblical Interpretation* (Grand Rapids, MI: Zondervan Publishing House, 1988), 24.
19. Ibid.
20. In the final analysis the ultimate conclusion about the final norm for scientific views and religious faith is probably made on the basis of the conviction, or presupposition, of the interpreter's stance on the authority levels of science and faith. We must also contend that science is constantly in flux and makes no absolute claims.
21. John C. L. Gibson, *Genesis*, The Daily Study Bible, vol. 1 (Edinburgh: The Saint Andrews Press, 1981), 56.
22. Ibid., 55.
23. Ibid.
24. Hansjörg Bräumer, *Das erst Buch Mose*. Wuppertaler Studienbibel, Kapitel 1-11 (Wuppertal: R. Brockhaus Verlag, 1983), 44.
25. D. Stuart Briscoe, *Genesis*, The Communicator's Commentary (Waco, TX: Word Books, 1987), 37.
26. Note the very useful discussion of the various groups and definitions of concordism by (a) John T. Baldwin, "Inspiration, the Natural Sciences, and a Window of Opportunity," *Journal of the Adventist Theological Society* 5/1 (1994), 131-154, esp. 139-43; (b) Davis A. Young, "The Discovery of Terrestrial History," *Portraits of Creation: Biblical and Scientific Perspectives on the World's Formation*, eds. Howard J. Van Till, Robert E. Snow, John H. Stek, and Davis A. Young (Grand Rapids, MI: Wm. B. Eerdmans Publishing Co., 1990), 27 n. 2; (c) Clark Pinnock, "Climbing out of a Swamp: The Evangelical Struggle to Understand the Creation Texts," *Interpretation* 43/2 (1989):143-155.
27. For example, Derek Kidner, *Genesis: An Introduction and a Commentary*, Tyndale Old Testament Commentaries (Chicago: InterVarsity Press, 1967), 56.
28. Victor P. Hamilton, *The Book of Genesis: Chapters 1-17*, The New International Commentary of the Old Testament (Grand Rapids, MI: Wm. B. Eerdmans Publishing Co., 1990), 54.
29. For a critique of other aspects of the "day/age theory," see Lloyd R. Bailey, *Genesis, Creation, and Creationism* (NY/Malwah, NJ: Paulist Press, 1993), 125-128.
30. Ibid., 126.
31. See above n. 13; cf. Carl F. H. Henry, *God Who Stands and Stays*, vol. 6 of God, Revelation and Authority (Waco, TX: Word Books, 1983), 2:112.
32. Reprinted in R. J. Wiseman, *Clues to Creation in Genesis*, ed. Donald J. Wiseman (London: Marshall, Morgan & Scott, 1977), 109-207.

33. Kidner, 54.
34. Wiseman, 132-133.
35. (a) William L. Holladay, Jr., *A Concise Hebrew and Aramaic Lexicon of the Old Testament* (Grand Rapids, MI: Wm. B. Eerdmans Publishing Co., 1971), 284-285; (b) Francis Brown, S.R. Driver, and Charles A. Briggs, *A Hebrew and English Lexicon of the Old Testament* (Oxford: Clarendon Press, 1974), 793-795; etc. See also (c) Helmer Ringgren, "asah," in *Theologisches Wörterbuch des alten Testaments*, eds. G. Johannes Botterweck and Helmer Ringgren (Stuttgart: W. Kohlhammer, 1987), 6:413-432.
36. Marcus Jastrow, *Dictionary of the Targumim, the Talmud Babli and Yerushalmi, and the Midrashic Literature* (NY: Pardes Publishing House, 1943), 2:1124-1125.
37. A recent exception is Duane Garrett, *Rethinking Genesis: the Sources and Authorship of the First Book of the Pentateuch* (Grand Rapids, MI: Baker Book House, 1991), 192-194, who recognizes that Wiseman's "presentation was somewhat confused, however, and did not persuade many" (193 n. 12). Garrett seeks to bolster the idea of "days" as "seven days of divine revelation to Moses" with form-critical arguments, an attempt quite problematical in itself.
38. Davis, 27 n. 2.
39. Hamilton, 54-55.
40. *Ibid.*, 55.
41. *Ibid.*, 55-56.
42. Hamilton, 56 n. 1, refers to C. E. Hummel, "Interpreting Genesis 1," *Journal of the American Scientific Affiliation* 38 (1986): 175-186.
43. Hummel, *The Galileo Connection*, 214 (*italics his*).
44. *Ibid.*, 215.
45. *Ibid.*
46. *Ibid.*, 213-216.
47. *Ibid.*, 214.
48. *Ibid.*, 213.
49. See the recent translations of Gunkel's major study, Hermann Gunkel, *The Folktales in the Old Testament*, trans. Michael D. Rutter (Sheffield: Almond Press, 1987). Excellent analyses and critiques of form criticism are provided by Patricia G. Kirkpatrick, *The Old Testament and Folklore Study* (Sheffield: JSOT Press, 1987) and especially Carrett, 35-50.
50. Hermann Gunkel, *The Legends of Genesis: The Biblical Saga and History* (NY: Schocken Books, 1964), 1.
51. *Ibid.*, 7.
52. See the penetrating discussion of Jerome Hamer, *Karl Barth* (Westminster, MD: Newman Press, 1962), 119-122.
53. S.H. Hooke, *Middle Eastern Mythology* (Baltimore, MD: Penguin Books, 1963), 119-121.
54. Gordon J. Wenham, *Genesis 1-15*, Word Biblical Commentary, vol. 1: Genesis (Waco, TX: Word Books, 1987), 10.
55. Walter Brueggemann, *Genesis: A Bible Commentary for Teaching and Preaching* (Atlanta GA: John Knox Press, 1982), 26.
56. Claus Westermann, *Genesis 1-11: A Commentary* (London: SPCK Press, 1984), 80.
57. John H. Stek, "What Says Scripture?" *Portraits of Creation*, 236.



58. Gerhard von Rad, *Genesis: A Commentary* (Philadelphia: Westminster Press, 1972), 65.
59. At present (a) Conrad Hyers, *The Meaning of Creation: Genesis and Modern Science* (Atlanta: John Knox Press, 1984), 93-114; (b) Susan Niditch, *Chaos to Cosmos: Studies in Biblical Patterns of Creation* (Chico, CA: Scholars Press, 1985); and many others. Scholars have a most difficult time defining what is meant by "myth." G.B. Caird (*The Language and Imagery of the Bible* [Philadelphia: Westminster Press, 1980], 219-224) has identified nine different definitions of myth, and John W. Rogerson (*Myth in Old Testament Interpretation* [Berlin: W. de Gruyter 1974], 274-278) has pointed to twelve aspects of myth. Genesis 1-11 is removed from the concept of myth (see Benedikt Otzen, Hans Gottlieb, and Knud Jeppesen, *Myths in the Old Testament* [London: SCM Press, 1980]).
60. (a) Gibson, 55; (b) Donald D. Evans, *The Logic of Self-Involvement* (London: SCM Press, 1963), 242-252.
61. J.A. Thompson, "Genesis 1-3. Science? History? Theology," *Theological Review* 3 (1966): 25.
62. The genre/form approach so widely used today, especially by critical scholars but also employed for other reasons by some evangelicals to Genesis 1, is formally identical or closely associated with the demythologization program of Rudolph Bultmann. He demythologizes the New Testament at any place where it does not conform to the worldview of modern man. Thus, the resurrection narrative is demythologized in such a way that the resurrection never took place in a literal sense. Evangelicals have to be aware that they cannot demythologize Genesis 1 without carrying this over to the New Testament.
63. Noel Weeks, "The Hermeneutical Problem of Genesis 1-11," *Themelios* 4/1 (1978): 14.
64. See Norman C. Habel, *Literary Criticism of the Old Testament* (Philadelphia: Fortress Press, 1971), 69-70.
65. We do not address the question of a structural interpretation of Genesis 1 by the method of structuralism which seeks to expose the alleged deep structures of a text. The subsequent method of deconstructionism in linguistics "is an attempt to undermine the reader's expectations that a text will communicate some independently existing truth, by showing that author and reader alike are caught in the system of constraints imposed by the linguistic and literary system to which they belong, and are capable of communicating or receiving only such meanings as the system makes possible" (John Barton, "Structuralism," *Anchor Bible Dictionary*, ed. David N. Freedman [NY: Doubleday, 1992], 6:216; cf. Jonathan D. Culler, *The Pursuit of Signs: Semiotics, Literature, Deconstruction* [Ithaca: Cornell University Press, 1981]). Just as deconstructionism denies to any text a fixed and stable meaning so in "reader-response criticism" the idea of a fixed meaning of a text is given up as well (see J. Severino Croatto, *Biblical Hermeneutics: Toward a Theory of Reading as the Production of Meaning* [Maryknoll, NY: Orbis Books, 1987]; Edgar V. McKnight, *The Postmodern Use of the Bible: The Emergence of Reader-Oriented Criticism* [Nashville, TN: Abingdon Press, 1988]).
66. Paul D. Hanson, "Theology, Old Testament," *Harper's Dictionary of the Bible*, ed. Paul Achtemeier (San Francisco: Harper & Row, 1987), 1059: "We have already observed that every scholarly endeavor inevitably is based upon presuppositions. This is already true on the level of the descriptive task with which OT theology begins. For example, the scholar who accepts Ernst Troeltsch's 'analogy principle' (i.e., to be credible, a happening recorded in a historical source must have parallels in modern experience) will dismiss all reconstructions of the Exodus from Egypt or the resurrection of Jesus, which defy explanation within the nexus of cause and effect as understood by modern science, whereas others may not be so bound."

67. Van A. Harvey, *The Historian and the Believer* (NY: Macmillan, 1966), 43-64.
68. Edward H. Carr, *What Is History?* (Harmondsworth: Penguin Books, 1964), 87-108.
69. Edward Krentz, *The Historical-Critical Method* (Philadelphia: Fortress Press, 1975), 57.
70. R.G. Collingwood, *The Idea of History* (London: Oxford University Press, 1956), 240.
71. For a critique of the principle of analogy, see (a) T. Peters, "The Use of Analogy in Historical Method," *Catholic Biblical Quarterly* 35 (1973): 473-482; (b) Wolfhart Pannenberg, *Questions in Theology* (Philadelphia: Westminster Press, 1970), 1:39-53.
72. See the classical study by William Henry Green, *The Unity of the Book of Genesis* (1895; reprint, Grand Rapids, MI: Baker Book House, 1979).
73. Walter C. Kaiser, "The Literary Form of Genesis 1-11," *New Perspectives on the Old Testament*, ed. J. Barton Payne (Waco, TX: Word Books, 1970), 61.
74. Jacques B. Doukhan, *The Genesis Creation Story: Its Literary Structure*, Andrews University Seminary Doctoral Dissertation Series (Berrien Springs, MI: Andrews University Press, 1978), 5:182.
75. Gunkel, *Legends*, 38.
76. Garrett, 192.
77. Gerhard F. Hasel, "The Polemical Nature of the Genesis Cosmology," *Evangelical Quarterly* 46 (1974), 81-102, pointed out that there are a number of explicit and implicit polemical emphases in Genesis 1. This fact does not diminish in the least the biblical author's intention to write an account that has a literal intent to provide factual and historical information.
78. Stek, 241.
79. Hummel, *The Galileo Connection*, 216: "Genesis 1 contrasts sharply with the cyclical, recurring creations described by Israel's pagan neighbors."
80. It is neither "metahistory" which is removed from real history, nor "salvation history" which never happened in the way it is written in the Old Testament. Cf. Robert Gnuse, *Heilsgeschichte as a Model for Biblical Theology* (Lanham, MD: University Press of America, 1989).
81. von Rad, 65.
82. Wenham, 19.
83. James Barr, *Fundamentalism* (Philadelphia: Westminster Press, 1978), 40-43.
84. Hermann Gunkel, *Genesis übersetzt und erklärt* (Göttingen: Vandenhoeck & Ruprecht, 1901), 97.
85. Hamilton, 53.
86. Stek, 237-238.
87. Benedickt Hartmann, Philippe Reymond, and Johann Jakob Stamm, *Hebräisches und Aramäisches Wörterbuch der Hebräischen Sprache* (Leiden: E.J. Brill, 1990), 382. Hereafter cited as HAL. Its predecessor, i.e., by Ludwig Koehler and Walter Baumgartner, *Lexicon in Veteris Testamenti Libros* (Leiden: E.J. Brill, 1958), 372, reads "day (of 24 hours)" for the creation day.
88. William H. Holladay, *A Concise Hebrew and Aramaic Lexicon of the Old Testament* (Grand Rapids, MI: Wm. B. Eerdmans Publishing Co., 1971), 130.
89. Brown, Driver and Briggs, 398.

90. Magne Saeboe, "yôm," in *Theological Dictionary of the Old Testament*, eds. G. Johannes Botterweck and Helmer Ringgren (Grand Rapids, MI: Wm. B. Eerdmans Publishing Co., 1990), 6:23.
91. Ernst Jenni, "jom Tag," *Theologisches Handwörterbuch zum Alten Testament*, eds. Ernst Jenni and Claus Westermann (Zurich/Munich: Theologischer Verlag, 1971) 1:709.
92. James Barr, *The Semantics of Biblical Language*, 3rd ed. (London: SCM Press, 1991), 1.
93. Ibid.
94. (a) *HAL*, 382-384; (b) Brown, Driver and Briggs, 398-401.
95. Saeboe, 14.
96. Ibid., 15.; "... in the Hebrew OT, 1,057 (45.9%) involve a preposition (esp. with the singular)."
97. Ibid., 14-20.
98. E. Kautzsch and A. E. Cowley, eds., *Gesenius' Hebrew Grammar*, 2d. ed. (Oxford: Clarendon Press, 1910), 347 § 114e: "This use of the infinitive construct is especially frequent in connection with *be* or *ke* to express time-determinations (in English resolved into a temporal clause, ...) ...."
99. Westermann, 198.
100. Saeboe, 15.
101. (a) Ibid., 13; (b) Jenni, 708.
102. Jenni, 707, notes that there are only four nouns used more often in the Old Testament.
103. Ibid., 708.
104. Stek, 237, is correct in noting that each "day" of creation has to be the same since the "evening and morning" time expression and the numeral is in each instance identical. In other words, each creation "day" is of equal length. From this he shows that it is not defensible to argue that the first three "days" were long periods of time while the remaining "days" were 24-hour days. The latter position was argued by Edward J. Young, *Studies in Genesis One* (Philadelphia: Presbyterian and Reformed Publishing House, 1964), 104, and has found a recent supporter in R. Clyde McCone, "Were the Days of Creation Twenty-four Hours Long?" *The Genesis Debate*, 24.  
 Young and followers are inclined to separate the lengths of creation days because they claim that the sun and moon had not been created yet until the fourth day. The question really is whether this is the case. It seems likely that on the fourth day God appointed the sun and moon to rule the day and night respectively. This appointment to the ruling function does not negate that the sun and moon were in existence before. It is possible that they were not visible to the human eye before the fourth day. Some have for this reason suggested that there may have been a vapor or cloud cover before the fourth day.
105. Saeboe, 22-23.
106. Bruce K. Waltke, "yôm, day, time, year," *Theological Wordbook of the Old Testament*, ed. R. Laird Harris (Chicago: Moody Press, 1980), 371.
107. Hamilton, 54.
108. Ralph L. Smith, *Micah-Malachi*, Word Biblical Commentary (Waco, TX: Word Books, 1984), 277.
109. The other exception is with numbers above 1,000 in the apocalyptic text of Daniel 12:11-12 with the reference to 1,290 "days" and the 1,335 "days." There are some differences from Genesis 1. In both instances in Daniel 12 the plural form of "days" is employed in contrast to Genesis 1. In Genesis 1 the "day" refers to what has

- happened in the past; in Daniel 12 “days” refer to a prophetic time in the future. The context of all other prophetic time predictions in the book of Daniel makes it clear that in prophetic perspective each time element whether “times” (4:16,23, 25,32), “time, times and half a time” (7:25), “evening[s and] morning[s]” (8:14), “weeks” (9:24), and respectively “days” (12:11-12) stands for another reality in real historical time. In other words in Daniel the year/day principle is at work each time a time prophecy is provided. The Danielic apocalyptic context is different from the creation context of Genesis 1. Time at the beginning, in creation, is not identical with predictive time which finds its fulfillment in the historical future. There is nothing predictive in Genesis 1. The latter is a prose-record of the past and not apocalyptic prophecy of the future. These content and contextual perspectives do not warrant a departure from the plain meaning in the Genesis creation account.
110. In Genesis 1:31 the Hebrew has an article both before *yôm* and the numeral. In Genesis 2:3 the article is only before the numeral following the noun *yôm*. According to Hebrew syntax the article in the latter case makes the word which the numeral qualifies articular.
  111. Ronald E Youngblood, *The Book of Genesis*, 2d ed. (Grand Rapids, MI: Baker Book House, 1991), 26. Westermann, 76, actually translates “one day.”
  112. Youngblood, *Genesis*, 26.
  113. Bruce K. Waltke and M. O’Connor, *An Introduction to Biblical Hebrew Syntax* (Winona Lake, IN: Eisenbrauns, 1990), 274. The translation “day one” is syntactically not correct, even though the cardinal is used here. In clauses of the type of Genesis 1:5 the cardinal serves effectively as an ordinal number (Nahum M. Sarna, *Genesis*, The JPS Torah Commentary [Philadelphia: Jewish Publication Society, 1989], 8, 353).
  114. Youngblood, *Genesis*, 26.
  115. See Herbert Niehr, “*ereb*,” *Theologisches Wörterbuch zum Alten Testament*, 6:359-366.
  116. M. Barth, “*boqer*,” *Theological Dictionary of the Old Testament*, 2:225.
  117. Werner H. Schmidt, *Die Schöpfungsgeschichte der Priesterschrift*, 2d ed. (Neukirchen-Vluyn: Neukirchener Verlag, 1967), 68.
  118. See (a) Niels-Erik A. Andreasen, *The Old Testament Sabbath: A Tradition-Historical Interpretation*, SBL Dissertation Series No. 7 (Missoula, MT: Society of Biblical Literature, 1972), 174-202; (b) Gerhard F. Hasel, “The Sabbath in the Pentateuch,” *The Sabbath in Scripture and History*, ed. Kenneth A. Strand (Washington, DC: Review and Herald Publishing Association, 1982), 21-43; (c) idem, “Sabbath,” *The Anchor Bible Dictionary*, 849-856; (d) Gnana Robinson, *The Origin and Development of the Old Testament Sabbath: A Comprehensive Exegetical Approach* (Frankfurt: Peter Lang, 1988), 139-142, 296-301.
  119. Schmidt, 68 n. 5.
  120. See also Weeks, 18: “The commandment loses completely its cogency if they [the ‘days’] are not taken literally.”
  121. Blocher, 48; see also Henricus Renckens, *Israel’s Concept of the Beginning: The Theology of Genesis 1-3* (NY: Herder & Herder, 1964), 98-100.
  122. Fretheim, 20.
  123. Bailey, 126.

# ANNOTATIONS FROM THE LITERATURE

## EVOLUTION

Nilsson D-E, Pelger S. 1994. A pessimistic estimate of the time required for an eye to evolve. *Proceedings of the Royal Society of London B* 256:53-58.

*Summary.* The origin of the vertebrate eye has been a conundrum for evolutionary biologists ever since Darwin. Nilsson and Pelger tackled the problem with a computer simulation in which the starting point is a flat patch of light-sensitive, pigmented epithelium. They then proceeded to cause the shape of the patch to vary by “mutations” of 1%, followed by “selection” of the most functional shape. Each step in the process was called a “generation.” They counted the number of “generations” required for the flat patch on the computer screen to change to the shape of the vertebrate eye. Along the way, they introduced a variation in refractive index, which eventually “developed” into a “lens.” The number of “generations” required to effect the change from a flat patch of photosensitive cells to a vertebrate eye with functional lens was calculated as about 364,000.

*Comment.* This report was received approvingly by Richard Dawkins (*Nature* 368:690-691). Various types of eyes are present in at least 40 independent “lineages,” which Dawkins believes shows that evolution of the eye cannot be terribly difficult. Nevertheless, both Dawkins and the authors of the report note that the model does not take certain features into consideration, such as the origins of the photosensitive patch of cells, the variable iris, or variable focusing. Perhaps analysis of these features will be forthcoming.

What is one to make of all this? First, comparing the evolution of the eye to shape changes on a computer screen seems rather far-fetched. The entire project seems closer to an exercise in geometry than in biology. Second, the exercise assumes a functional starting point. Thus it has nothing to do with the origin of the biochemical systems of vision or the requisite neural network. Third, Nilsson and Pelger’s computer exercise operates as if each 1% change in morphology can be accounted for by a single gene mutation. They do

not consider the effects of pleiotropy, genetic background, or developmental processes. Fourth, an important part of the model relies on the special circumstance of a layer of clear cells covering the “retina.” This layer somehow assumes the proper shape of a lens. Fifth, as noted by the authors, several features of the eye remain unaccounted for, such as the iris. Basically, the only result achieved was to show that two light-sensitive surfaces that differ in shape by 1% will have different efficiencies in photoreception, and that an uninterrupted series of 1% improvements is possible. The failure of scientists to produce new structures in selection experiments illustrates the implausibility of Nilsson and Pelger’s “just so” story.

Patterson C, Williams DM, Humphries CJ. 1993. Congruence between molecular and morphological phylogenies. *Annual Review of Ecology and Systematics* 24:153-188.

**Summary.** In 1987, Colin Patterson edited a book entitled “Molecules and morphology in evolution: conflict or compromise?” The general sense of the book was that evolutionary phylogenies based on molecular sequence were often different from those based on morphology. The present paper is a reassessment of the situation. Patterson et al. consider studies from the period 1987-1992, including both plants and animals, but not unicellular organisms, which lack sufficient morphological characters for a useful comparison.

**Comment.** Most of the discussion focuses on higher taxonomic categories, above the level of family. The degree of congruence between molecular and morphological phylogenies seems no better than reported previously in the 1987 book. Few taxonomic groups give completely consistent phylogenies when different methods are used. Disagreement seems to increase as more taxa are added, more characters are considered, and at higher taxonomic levels. Molecular phylogenies are as likely to disagree with each other as are morphological phylogenies. Typically, when all trees within 1% of the shortest tree are combined into a consensus tree, there is little structure left. The authors’ concluding statement suggests pessimism that evolutionists will ever be able to produce a single acceptable tree of relationships for all living organisms.

## GENETICS

Nowak R. 1994. Mining treasures from 'junk DNA.' *Science* 263:608-610.

**Summary.** The function of DNA has generally been seen as the production of proteins. Yet it appears that only a small proportion, thought to be perhaps 3%, of the DNA actually codes for proteins. What is the function of the rest of the DNA? Clearly, some DNA is involved in gene regulation, yet the function of a large proportion of the genome is still unknown. The apparent excess of DNA has been called "junk DNA."

Several explanations have been offered for the existence of "junk DNA": 1) it is largely parasite-like "selfish DNA"; 2) it is composed of "vestigial DNA" remaining from past evolutionary history; 3) it represents the evolutionary future, a kind of "lottery DNA" from which new genes may someday be produced.

**Comment.** Several types of "junk DNA" sequences have been described. Among these are introns, satellites, 3' untranslated regions, short and long interspersed elements, and pseudogenes. As knowledge of the genome has progressed, the proportion of "junk DNA" has decreased. For example, many introns appear to code for "small nucleolar RNAs," which might play a part in ribosome assembly. Satellite DNA might play a role in holding the chromosome together, especially at its ends and at the centromere. Defects in minisatellite and microsatellite DNA have been associated with cancer. Long and short interspersed DNA might also be associated with disease. Although no function is known for most pseudogenes, some of them have been found to be functional.

The functioning of the genetic system is turning out to be much more complex than previously realized. The chromosomes are no longer regarded as a series of genes like beads on a string. Instead, each chromosome is more like a complex "information organelle," with a structural organization that is only beginning to be understood, and with a complex, dynamic system of feedback and control of gene expression.

## PALEONTOLOGY

Fortelius M, Kappelman J. 1993. The largest land mammal ever imagined. *Zoological Journal of the Linnean Society* 107:85-101.

**Summary.** It has been said that the largest mammal that ever lived was an extinct giant rhinoceros-like animal named *Indricotherium* (or “*Baluchitherium*”). Estimates of its weight have ranged as high as 30 tons. This estimate has been revised down to an average of 11 tons, with a maximum of less than 20 tons. Although *Indricotherium* is truly a giant, it is little or no larger than the largest known fossil elephants.

## SCIENCE AND RELIGION

Yang S-H. 1993. Radiocarbon dating and American evangelical Christians. *Perspectives on Science and Christian Faith* 45:229-240.

**Summary.** The development of radiocarbon dating presented young-earth creationists with a challenge to their understanding of the age of Earth. Yang outlines the reactions of four different creationist groups: Seventh-day Adventists (SDAs), the American Scientific Affiliation (ASA), the Creation Research Society (CRS), and the Institute for Creation Research (ICR). All four groups publish journals that discuss issues in creation and evolution.

**Comment.** In 1958 SDAs established the Geoscience Research Institute (GRI) for the purpose of studying issues raised by science. Some SDA scholars challenged the church’s position of a recent creation, but the issue was too fundamental to the church’s doctrinal structure to permit the church to accommodate such a change. The GRI maintains a position that includes a recent creation and a worldwide flood. The ASA became more sympathetic to the concept of an old earth, members variously adopting such explanations as the “gap theory” (pre-Adamic creation and destruction) and the “day-age” theory (each creation day represents an indefinite period of time). Dissident members of the ASA formed their own groups, the CRS in 1963 and the ICR in 1972. The ICR has established its own radiocarbon laboratory in an effort to test the assumptions of the carbon-14 dating method. Yang mentions specific individuals and describes their respective positions, but does not attempt to evaluate the positions taken by the various organizations.



## LITERATURE REVIEWS

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

### THE RECORD OF LIFE: HOW EXPLAIN?

THE BOOK OF LIFE — AN ILLUSTRATED HISTORY OF THE EVOLUTION OF LIFE ON EARTH. S. J. Gould (general editor). 1993. NY: W.W. Norton. 256 p. Cloth, \$40.00.

*Reviewed by John Hadd*

*John R. Hadd, a long-time student of the creationist-evolutionist argument, has authored Evolution: Reconciling the Controversy. His second book, further examining the central issues, is nearing completion.*

©1994 by John R. Hadd

*The Book of Life — An Illustrated History of the Evolution of Life on Earth* is a luxuriant treatment of a topic of incalculable importance. General editor Stephen Jay Gould has marshaled the talents of a select group of American, Canadian and British scientists and illustrators to present this volume, heralded as a fusion of artistic excellence and accurate, state-of-the-art scientific knowledge.

### CONTENTS AND REVIEWER RECEPTION

The work begins with an overview essay explaining limitations in past attempts at panoramic portrayal of Earth's life forms. In the second chapter the reader is given solid grounding in evolutionist conceptions of geologic time and for the basic structure of the fossil record. The third chapter is devoted to "foundations" for Earth life and its initial appearance in primordial oceans. Coverage of the remaining five chapters is largely indicated by their titles: "The Rise of the Fishes," "Four Feet on the Ground" (the emergence of amphibians), "Dinosaur Summer," "Victors by Default" (mammalian succession of the dinosaur dynasties), and "The Primates' Progress" (from hominoid primates to

*Homo sapiens*). The reviewer for *Booklist* characterized the effort as “marvelous.... The modesty of this first-rank team of scientists and illustrators makes all the more trustworthy their seven-chapter telling of the evolution story.”

The text and art are blended in stimulating fashion. The chapters are illuminated by more than 300 superb paintings, drawings and computer-designed illustrations. The informational graphics cover a vast range of subject matter, from skeletal evolution to continental drift, resulting, in the judgment of *The Washington Post*, in “a volume with the visual impact of an art book, the conceptual density of a college text and the narrative pounce of a novel.”

*The Book of Life* is intended to give representation to naturalistic evolutionary theory, neo-Darwinism, and is entirely consistent with other recent statements by the American scientific establishment, such as *Science and Creationism: A View from the National Academy of Sciences*<sup>1</sup> and *Project 2061: Science for All Americans*.<sup>2</sup> These publications, in turn, provide the foundation for the evolution component of the *Science Framework for California Public Schools*, a prospective guide to national curriculum standards for public schools.<sup>3</sup>

So far as I know, *The Book of Life* has been accorded unanimously favorable review. Of the accolades and endorsements which I have seen, the emphasis of The History Book Club, which featured the work, is presently most important. HBC emphasized the criticality of truth-telling, concluding its synopsis: “the emphasis today is on the true story, which is the *raison d’etre* for this book.” I will next explain why I believe *The Book of Life* falls far short of the unexceptionable standard of telling the truth — the scientific truth pertaining to Earth’s record of life.

## FAULTS

*The Book of Life* is a superior *depiction* of the evidence from the fossil record for dramatic change in Earth’s life forms. However, three huge, related omissions or misrepresentations fatally impact its plausibility to *explain* the stupendous fossil record.

**First: Treatment of the Origin of Life.** In the second chapter (“Foundations: Life in the Oceans”), it is acknowledged that no one “has created life in a test tube, and there is much we do not understand about how organic molecules assembled into primitive life forms 4 billion years ago” (p 42). Despite that disclaimer, the clearly intended

impression is that life began in the depths of the oceans when purely chemical reactions spawned the first fossil-recorded prokaryotic cells. The origin of life is proposed as an entirely natural transaction. “Modern bacteria ... hold the key. Many versatile species of these tiny organisms find sources of chemical energy completely separate from the oxygen we [humans] require” (p 42).

This claim on behalf of an abiogenetic explanation for the origin of life is, without exaggeration, an enormous scientific travesty.<sup>4</sup> Unimpeachable scientific criticisms of the concept of abiogenesis are myriad. Were the authors of *The Book of Life* not aware of them? If so, theirs can hardly qualify as a state-of-the-art presentation of scientific knowledge. Or did they choose simply to disregard them, thereby revealing dogmatic disdain for “nonconforming” data? Whatever accounts for it, *The Book of Life* is anything but truthful in reporting on contemporary knowledge regarding the origin of life.

### **Second: Treatment of Genetic Information/Intelligence.**

Darwin’s theory for explaining the record of life involved a heterogeneous set of components, as explained by Ernst Mayr:

*[O]rganic evolution consists of two essentially independent processes, transformations in time and diversification in (ecological and geographical) space. The two processes require a minimum of two entirely independent and very different theories.*<sup>5</sup>

The fossil record documents distinct transformations in time for Earth’s life forms. Every instance of such documentation implies directly that living things either acquired new genetic information, or their stored information underwent significant alteration. Such transactions must be assessed not only in terms of biology and genetic mutations, but also at least two basic principles of communications science. One: *Information does not and cannot arise spontaneously.* To attribute the production of new information to undirected chance, as neo-Darwinians are prone to do, is to commit heresy in the school of contemporary communications science. Two: *Random change in genetic information (DNA symbol sequences) would relentlessly destroy meaning.* “No currently existing formal language can tolerate random changes in the symbol sequences which express its sentences. Meaning is almost invariably destroyed. Any changes must be syntactically lawful ones.”<sup>6</sup>

All Darwinists assume increasing complexity in life forms and the record of life, yet they have no explanation for the assumptions congruent with the principles of communications science.<sup>7</sup> The Index to *The Book of Life* contains an entry for “genetic blueprints,” but that reference alludes only to a brief comment in the text. Along with less than a half-dozen similar terms scattered throughout the book, that is all the volume contains that can be conceivably related to genetically formative “transformations in time.” In this regard *The Book of Life* fits perfectly with the genre of naturalistic evolutionary tomes which are grossly deficient — if not totally silent — in relation to the nonmaterial information/intelligence factor so enormously involved in the makeup of the fossil record of life.<sup>8</sup>

**Third: The Appearance of New, Distinct Life.** Darwin could “see no limit” to the extent of natural change in life forms. Neither, it appears, can the authors of *The Book of Life* discern (or admit to) a limit. This “analytic” treatment shows most prominently with respect to the dinosaurs.

We are assured that the dinosaurs were “strikingly” new in appearance, “the most powerful and innovative newcomers in the late Triassic” (p 125). Then we are advised that their appearance was but natural; the dinosaurs self-willed themselves and their position:

*Of all the animals that survived to radiate into the ecospace created by the mass extinction of the end-Carnian phase, one group seized the time. Chance made the opportunity, but the dinosaurs took it. (p 25).*

Natural forces, alone, can destroy life. But nature cannot generate genetically distinct life forms, and there are real limits to life-form variability. Nature’s potency for birthing variety is both enormous — and restricted. This is a conclusive judgment, buttressed by firm, in-hand empirical scientific evidence.<sup>9</sup> Such evidence confirms that claims as made in *The Book of Life* for the appearance of the dinosaurs illustrate nothing but naturalistic philosophical dogma.

## CONCLUSION

The explanatory power of naturalistic evolutionary theory is tied directly to the presence of the fossil record of life.

*This is the theory that the world is neither constant nor perpetually cycling but rather is steadily and perhaps*

*directionally changing, and that organisms are being transformed in time.... The changes documented by the fossil record in precisely dated geologic strata are a fact that we designate as evolution.*<sup>10</sup>

I submit that naturalistic evolutionary theory in general, and neo-Darwinism specifically, embodying a principled disregard of non-material factors which must be accounted for in the intelligence/informational workings of life, is *inherently incapable* of persuasively explaining Earth's fossil record of life. Said a bit differently, naturalistic evolutionary theory cannot provide a scientifically defensible explanation of its primary justification for being! It has been very correctly I noted that Darwinism is presently in substantial control of the Western world's intellectual establishment. Yet such control, it must be underscored, involves an historically classic case of governance by an emperor without clothing, a conceptual governor naked to the challenge of relevant, contemporary scientific evidence implied in the book. By its failure to heed those evidences; by not adhering to the standard of truth, however limited, but still sure human knowledge; *The Book of Life* invites, and deserves, censure for posing as an explanation of the record of life.

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## LITERATURE REVIEWS

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### CHALLENGING THE CREED: DOUBTS ABOUT PLATE TECTONICS?

NEW CONCEPTS IN GLOBAL TECTONICS. S. Chatterjee and N. Hutton, editors. 1992. Lubbock, TX: Texas Tech University Press. 449 p. Cloth, \$65.

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

The theory of plate tectonics is now so widely accepted that it may come as a surprise to discover that some scientists remain unconvinced. Several of those scientists have produced a book explaining their concerns. The book is a compilation of 23 papers, most of which are critical of plate tectonics theory, although all the authors accept the premise that Earth's surface has a long, dynamic history. Alternative models favored by various authors include a "rapidly" expanding Earth, a "slowly" expanding Earth, a contracting Earth, and a model called "surge tectonics."

Several criticisms of sea-floor spreading theory are presented. Probably the most significant is the claim that granitic material is found in the ocean floor not far from the Atlantic Ridge. If the examples are valid, this would seem to be fatal to the standard interpretation of sea-floor spreading. However, one would want to be certain the continental rocks reported from along the Atlantic ridge were *in situ*, rather than transported from the continents. The strongest claim seems to be "Bald Mountain," supposedly 13 km across, near the Azores, which is close to the ridge. The presence of autochthonous continental material here of would seem to require a change in the standard interpretation of plate tectonics.

Questions are also raised about magnetic properties of ocean-floor rocks. The nature of magnetism seems related to other phenomena. For example, normal magnetic polarity seems associated with high heat flow, hot-spot volcanism, fast sea-floor spreading, and rapid rates of subsidence of cratonic basins. Volcanic quiescence seems correlated with reverse magnetic fields, yet while most of the Hawaiian-Emperor chain was formed during normal polarity, reverse polarity is considered to have occupied an equal amount of time during their formation. Another criticism is that intraplate activity is not explained by plate tectonics, a fact that is already well-known. Examples include: formation of intracratonic basins; midcontinental earthquakes, such as the New Madrid quake; seismicity of Ninety-East Ridge; and activity on the floor of the Indian plate.

The mechanism driving plate movement has never been satisfactorily determined. The criticism here is that ridge push seems to be more important than subduction pull. For example, subduction pull cannot explain how continental collision of India with Asia could result in formation of the Himalayas. Compression, rather than tension, also seems to predominate in Australia and between it and Tasmania. On the other hand, the Tibetan Plateau seems under tension rather than compression.

Certain stratigraphic levels seem to be characterized by similar effects worldwide. Several examples are given: every Tithonian (uppermost Jurassic) to Eocene foldbelt has an angular unconformity between the middle part of the Lower Eocene and the middle part of the Upper Eocene; a “bonarelli anoxic level” is present in the Cenomanian-Turonian (lower Upper Cretaceous) in mid-ocean plateaus of the Pacific Basin, the deep Atlantic Ocean, cratonic interior seaways of North America and Europe, African marginal embayments, and the Tethyan margins; worldwide occurrences of crustal shortening during Aptian-Albian (uppermost Lower Cretaceous); inversion of the direction of tilting at nearly all passive margins during the Aptian; large-scale Alpine-type orogeny and crustal shortening and a change in stress patterns in Middle to Upper Eocene; a maximum in the abundance of depositional hiatuses occurred in the Upper Miocene of all ocean basins except the Indian Ocean. These global effects suggest global causes. Episodes of world-wide crustal activity imply global catastrophism, not slow movement of continents. The most plausible source of the



energy required for global crustal activity seems to be extraterrestrial impacts. A near fly-by of a large object might probably perturb Earth's rotation sufficiently to cause global crustal activity.

The opinions of the authors of this book are undoubtedly outside the mainstream of current thinking, and some of the arguments presented are not persuasive. However, the book makes for stimulating reading, and performs the very useful function of reminding us that theories may appear to be well-established, yet may have significant shortcomings.

# GENERAL SCIENCE NOTES

## INCOMPLETE ECOSYSTEMS

*By Ariel A. Roth, Geoscience Research Institute*

### WHAT THIS ARTICLE IS ABOUT

*Animals depend on plants as a source for food. Without food animals cannot survive. When the fossil record is examined, one finds some assemblages that are ecologically incomplete. In particular, in some localities there does not seem to be enough plants to support the animals represented as fossils. How could the animals survive the long ages postulated without adequate food? A model involving transport, sorting and deposition by the waters of the Genesis flood can resolve the dilemma.*

All living organisms need a source of energy to remain alive. There are many ways whereby they obtain this energy by following various pathways of the food chain. Plants are by far the main primary producers of food. They take approximately 1% of the light energy from the sun that falls on them and convert it to organic compounds that serve as food for many animals and also for some non-photosynthetic plants such as mushrooms. On the other hand, carnivorous animals obtain their energy by eating other animals, and a few carnivorous plants eat animals. Because of a variety of energy relationships, the food chain is sometimes referred to as the food web. The food chain can be generalized to the simple fact that almost all animals obtain their energy directly or indirectly from plants. An exception would be the large, 1.3-meter tubeworms that live deep in the ocean along warm water vents where there is no light. They obtain their energy from bacteria which in turn obtain their energy from sulphur compounds; but on land, animals obtain their energy from plants. Without plants, most other organisms cannot survive.

The fact that animals need plants poses a problem for the evolutionary model, since the record of past life sometimes reveals non-viable “ecologic systems.” The discrepancy is especially striking where we find few or no fossil plants to serve as food for fossil animals that are well represented. When you consider, as evolutionary theory proposes,



**FIGURE 1. View of a small portion of the Morrison Formation near the town of Kayenta, Arizona. The lighter-shaded layers in the foreground below the darker steep cliffs are Morrison, including the hill in the foreground towards the right, which shows typical Morrison layers. The Morrison Formation, famous for its dinosaur bones, covers some 1,000,000 km<sup>2</sup> in the western United States and Canada.**

that these incomplete environments would have existed for millions of years, you have a problem. How did the animals survive?

Those who believe in creation and the biblical flood see this as evidence that various kinds of organisms might have been transported and sorted by the waters of the flood. Lighter plant material could be transported away from the animals, to be later changed to coal. Some of the unusually thick coal beds we find today suggest unusual accumulation conditions, as would be expected in a flood. One example is found in Australia, where the Morewell coal seam reaches at least 165 m (540 ft) in thickness.

The rock layers known as the Morrison Formation (Figure 1) of western North America appear to present a vast inadequate ecological system. The Formation has an average thickness of 100 m (300 ft) and extends over 1,000,000 km<sup>2</sup> (400,000 mi<sup>2</sup>), being found from Canada to Texas. It is most famous because it harbors a number of important dinosaur bone localities. It has been one of the world's richest sources

of dinosaur fossils (Figure 2). Yet plants are rare, notably where the dinosaurs are found.<sup>1</sup> What did these behemoths eat? The paleontologist Theodore White comments that: “Although the Morrison plain was an area of reasonably rapid accumulation of sediment, identifiable plant fossils are practically nonexistent.”<sup>2</sup> He further muses that by comparing to elephants the dinosaur *Apatosaurus* “would consume 3½ tons of green fodder daily.” If dinosaurs were living where their fossils are now found, what did they eat if plant fossils are so rare? It would take a large number of plants to support just one dinosaur.

Other investigators have also commented on this lack of plant fossils. One states that the Morrison in Montana “is practically barren of plant fossils throughout most of its sequence,”<sup>3</sup> and others comment that the “absence of evidence for abundant plant life in the form of coal beds and organic rich clays in much of the Morrison is puzzling.”<sup>4</sup> These workers also express their “frustration” because 10 of 12 samples studied microscopically were essentially barren of the “palynomorphs” (pollen and spores) which are produced by plants. With such a sparse source of energy, one wonders how the large dinosaurs could survive the assumed long ages while the Morrison Formation was being deposited. To explain the dilemma, the suggestion has been made that plants were

**FIGURE 2. Dinosaur bones from the Morrison Formation at Dinosaur National Monument near Vernal, Utah. Some of the longer bones are well over a meter (3-4 ft) long. Photograph by L. Jim Gibson.**





**FIGURE 3. View from the South Rim of the Grand Canyon of the Colorado River. The Coconino Sandstone is the prominent, widespread, whitish layer seen across the canyon near the top, but not at the very top, of the canyon wall.**

not preserved as fossils. This does not seem to be the case, since a number of animals and a few plants are well preserved. The Morrison might not be a place where dinosaurs lived, but instead represents a flood burial ground for dinosaurs, while plants were transported elsewhere.

Even more surprising are the data from the Coconino Sandstone, which is the widespread light-colored rock unit seen near the top of the rim of the Grand Canyon in Arizona (Figure 3). This unit, which averages around 150 m (500 ft) in thickness is spread over many thousands of square kilometers. Many hundreds — most likely thousands — of footprint trackways (Figure 4), probably made by amphibians or reptiles, occur in the lower half of the Coconino. Yet it appears that no plants were present. Aside from the footprints, only a few worm tubes and invertebrate tracks have been reported.<sup>5</sup> What did the animals who made all these tracks feed on? They had to have some food, but it is not there. If simple footprints are well preserved, so should the imprints of leaves and stems of plants, if they were present.

Almost all of the trackways in the Coconino indicate that the animals were going uphill,<sup>6</sup> and this same situation is found in the De Chelly Sandstone formation to the east.<sup>7</sup> The animals forming the tracks in the





**FIGURE 4. Animal trackways in the Coconino Sandstone in the southwest United States. Note both the small and large trackways. The largest footprints are about 2 cm wide. This set of trackways is now displayed at the Raymond Alf Museum, Claremont, California. Photograph by Leonard Brand.**

Coconino have not been found, but their tracks are well preserved and abundant. Furthermore, there is strong evidence that these trackways were formed underwater,<sup>8</sup> instead of the usual interpretation that they were formed on desert dunes. Is it possible that all these uphill trackways could have been formed by animals escaping the waters of the flood?

Regardless of these details, the absence or scarcity of plants in the Coconino Sandstone and Morrison Formation illustrate incomplete ecosystems which would not have been able to support normal animal life over the millions of years purported for the deposition of these geologic layers. The data seem to fit better with the biblical model of the flood than with the evolutionary model of long ages of slow development.

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# EDITORIAL

## NAME DROPPING

*Charles Darwin (1809-1882) is usually recognized as the one who provided the world with the theory of evolution. Students often learn about his famous world voyage as naturalist on the HMS Beagle. While visiting remote parts of the world he became convinced that species became modified over time. This variation served as a basis for his principle of survival of the fittest by natural selection. This concept was further interpreted by Darwin as an evolutionary mechanism that would provide for advanced forms of life without the need of a Creator God.*

*While other scientists had also contributed to the concept, Darwin soon gained notoriety and recognition for this major contribution to a “scientific” world view. His evolutionary mechanism is still widely accepted, although in recent years it has evoked significant criticism even from within the scientific community. Darwin has been, and still is, famous for being a thought leader who made a major contribution to the secularization movement during the past two centuries, especially in the Western world. Darwin’s notoriety has attracted a number of unwarranted and unwelcome “friends” who traded on his fame.*

*One of the more persistent themes, too often echoed by conservative religionists, is the story of Darwin’s deathbed confession. For more than a century allegations have been made that Darwin turned towards Christianity when he faced the end of his life. Over one hundred such accounts have been published. One clergyman reported this only a few days after Darwin’s death.*

*Probably the most important source of many such accounts is the famous “Lady Hope Story.” Lady Hope worked diligently for the cause of temperance, sometimes ministering to the drunkards and the destitute not too far from Darwin’s estate at Down in England. Darwin also had some interest in the cause of temperance. Lady Hope reports in detail a visit with Darwin in his home about six months before his death. According to her account, he was ill, but in good spirits, and had a Bible in hand. He spoke to her about the grandeur of the book of Hebrews and of salvation in Jesus Christ, but was pained when asked about creation. He expressed*



*surprise that some of his earlier queries and suggestions had spread like wildfire, and that people had made a religion of them.*

*The authenticity of this account has been much debated. The Darwin family has thoroughly denied it, although with inconsistencies. Some of the physical details given by Lady Hope leave little doubt that she had actually been in his home. A later version of this incident, also written by Lady Hope, differs in some details and suggests that there was more than one visit. The purported incident took place quite a long time before Darwin's death, hence is not a deathbed confession. There is no record of Darwin renouncing his views thereafter, and Darwin does not appear to have changed his mind on that point. His family has refuted any suggestion of a last-minute "conversion." Although we cannot be absolutely certain, the argument should not be used until good evidence can be brought forth. Unfortunately, the story has been used by many as evidence of the strength of the Christian gospel message. It is impressive to have the hero of evolution finally see the light of the gospel.*

*Secularists have also latched onto Darwin's fame in support of their world view. They usually deny the Lady Hope story and readily point to Darwin as one of their champions who helped emancipate humanity from religious superstition. Darwin's home at Down has become, in a sense, a shrine for rationalists and free thinkers; so much so that some tourists of a different mindset have been afraid to enter. However, Darwin's relation to the secularists has not been placid. When two atheists came to visit him at Down, he severely remonstrated with them for being so belligerent. He advocated passive agnosticism instead of aggressive atheism. A few months after this incident, Darwin died. Because of his fame he was given a religious State funeral with burial in Westminster Abbey. One secularist quipped that though the Church had Darwin's corpse, it did not have his ideas — ideas which were undermining its foundation.*

*To secularists Darwin was an ally, working for their cause. However, when Darwin's family published a "purified" version of his Life and Letters which over-emphasized his religious concerns, some freethinkers countered with a pamphlet that accused Darwin of hypocrisy, of lapsing from disbelief, and of yielding to the*

*pressure of the priests and their fire (pyre)! An unexpurgated version of his Life and Letters was not published until 76 years later. Nevertheless, since Darwin provided the secular community with a model for the origin of species that excluded God, Darwin's authority is readily appropriated in support of secular philosophy.*

*What were Darwin's real religious beliefs? While they are often summarized by the word "agnosticism", this is a gross oversimplification of the conflicts and changes that occurred over his lifetime.*

*While religious beliefs are difficult to discern with much accuracy, some facts shed light on this elusive question. Darwin had theological training at Cambridge University as he was preparing to become a country parson; however, his interest in natural history soon dominated. His wife was a devout Christian who worried about his eternal salvation. Darwin's children were christened at the Down church, and he gave generously to some of its activities, although he was not faithful in attendance. The question of religion in the Darwin home was a matter of tension which was not much discussed: Darwin and his sons tending more towards secularism, while his wife and daughters favored religion.*

*In his later years, Darwin thoroughly repudiated revelation and Christianity, but he remained open on the question of life after death. He shied away from controversy, the irreligious, and atheism, but he boasted of having "no remorse of having committed any great sin." While Darwin was somewhat despondent during his final year, one of his last utterances was "I am not the least afraid to die." It is also of interest that in the closing paragraph of the last five of the six editions of his famous book *On the Origin of Species*, Darwin casually refers to the Creator originating life. This still leaves intact his evolutionary concept for the origin of most life forms. The mixed picture one derives from these details indicates that Darwin is not one who should be claimed as the hero of either the secularists or the religionists. Actually, the popularity of evolution is probably due more to the work of secularists than to Charles Darwin.*

*We like to associate our views with the famous. This can lend credence both to our views and to ourselves. "Name dropping" is especially successful if the name being called is very famous. But is this being forthright, especially when the views of those with*

*whom we associate do not agree with the conclusions being emphasized? Accuracy is ill-served by such practices. Both the secularists and the religionists appear to have been misusing Darwin.*

*We can also learn other lessons from the incidents reported above: e.g., using care in formulating conclusions, and not being too gullible. The cause of truth would also be generously served if we would drop the practice of name dropping.*

*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: Hasel: the “Days” of Creation in Genesis 1: Literal “Days” or Figurative “Periods/Epochs” of Time?” (ORIGINS 21:5-38).**

I am convinced by the arguments advanced by the late Gerhard Hasel that the Hebrews believed that the days of Genesis 1 were literal, twenty-four hour days.

However, then unfortunately Dr. Hasel performs a great leap of faith. He states: “Genesis 1 is a factual account of the origin of the livable world. This record is accurate, authentic, and historical” (p 19). This is simply an assertion of Dr. Hasel. Conceptually and logically, it does not follow from a conclusion about the Hebrew belief concerning the nature of “days” in their creation account.

The Hebrews believed that the earth was fixed immovable in space. I wonder if Dr. Hasel would have stated that this is an “accurate and authentic” representation of reality. I suspect not.

R. Ervin Taylor  
Loma Linda, California

### **Editorial Response:**

*Unfortunately, Dr. Gerhard Hasel is unable to reply. A few comments from Dr. William Shea make a contribution to the discussion. They should not be construed as Dr. Hasel's interpretation.*

As an almost casual concluding comment, Dr. Taylor suggests that the Hebrews had the concept that Earth did not move. The inference is that their ancient views evidently conflict with modern science which says that Earth does move, both on its axis and around the sun.

Psalms 93:1 and Psalm 119:90 are often used to suggest that the Hebrews believed that Earth was fixed in space. Unfortunately, that is not what the texts are saying. Context and lexical use can provide assistance. In Psalm 93:1-2, the subject of meditation by the psalmist is first the majesty and power of God, and then His eternal existence. Verse 1a reflects upon the former, and verse 2 reflects upon the latter. The idea about the immovability of Earth is found in the thought pair of verse 1b. In this verse, the paired idea is that God established Earth. Thus the real extension of the idea is that God created and established Earth, and it continues because of that creation. This is indicated by the verb *mut*, which does not mean “to stand” or “stand still”; it means “to stagger, totter, waver, or wobble.”

In a positive sense *mut* is sometimes used in the Old Testament for earthquakes or the hearts of the wicked when they meet God in judgment. If

one wishes to address unscientific ideas, one should actually say that the Psalmist is denying the occurrence of any earthquakes in Israel. We know this is not the case, because the plate of the Jordan Rift Valley produces approximately five major earthquakes per century, and these were known and recognized in biblical times. This also is not the intent of the text.

Psalm 93:1-2 simply signifies that Earth was created and established by God, and, like its Creator, its establishment continues to this day. Not the earthquakes that cause it to go *mut*, nor even the floods of waters mentioned in the next two verses will disrupt what was established by God.

A very similar idea is found in Psalm 119:89-91. In this passage, the Psalmist reflects upon nature before he turns to the subject of the Torah in the next five verses. His reflection in this section begins with God's Word in the heavens: "For ever, O Lord, thy word [Hebrew, *dabar*] is firmly fixed in the heavens" (RSV). Does this mean that God's word, like congealed breath, stands in the heavens like an immovable Goodyear blimp while the sun, moon, and stars rotate around it? A literal-minded scientist might make such a conclusion, but the actual meaning is that the word spoken by God in heaven has eternal effects and is an ongoing rule for His creation.

Next comes the subject of God's truth. In verse 90, the literal Hebrew translates "from generation to generation (is) your '*emunah*.'" The first exegetical point is that the word generation is repeated, as is commonly done, to show the returning cycle of generation after generation, in essence from the Psalmist's generation to ours today. And still with all the generations that have come and gone, before and after the Psalmist, God's truth continues. The word use for that aspect of His nature is commonly translated, "steadiness, reliability, honesty, duty, faithfulness, security." Generations may come and go, but God goes on forever, and His truth continues through it all.

Earth then becomes an illustration of this continuing cycle: Earth was not just created and then eradicated. It still stands, it still exists, it still continues, just as God's truthful nature does. Of interest at this point is the poetic structure of the psalm. Earth — the object — is inserted between a pair of verbs. The first verb is a perfect for past action at a point of time; specifically, the time when God established Earth. The verb that follows the object and its conjunction is the verb "to stand" (*'amad*), used here in the imperfect, which if by itself would indicate continuing action or existence. What was established in the past — Earth at creation — continues in existence, and God's continuing nature and existence guarantees that Earth will still do so in the future. This verse is not talking about the rotation or celestial movement of the planet.

William H. Shea  
Biblical Research Institute  
Silver Spring, Maryland

# REACTIONS

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## **Re: Roth: Incomplete Ecosystems (ORIGINS 21:51-56).**

Dr. Roth has focused his attention on incomplete terrestrial ecosystems. Hopefully, he will in a future ORIGINS issue zero-in on incomplete marine ecosystems.

Dr. Roth mentions in passing a rare chemosynthetic-based food chain which occurs only at some submarine volcanic vents. Unmentioned is the fact that twice as much photosynthetic activity occurs in Earth's waters today as on its land. The marine photosynthesizers are largely composed of diatoms, dinoflagellates, and coccolithophorids. Their sunlit habitat necessarily occupies the upper few meters of the sea.

In the geologic column these photosynthesizing phyla appear no deeper than the lower Jurassic. The Devonian, lower on the geologic column and purportedly 200 million years older, harbors so much fish diversity it is called the "Age of Fishes." For those healthy Devonian fish there ought to be a complete food chain including a superabundance of photosynthesizers. The complete absence of floating photosynthesizers in the lower strata creates a "missing fish food" mystery for conventional geology.

A prominent evolutionist facing this mystery in the 1970s wrote: "We can only conclude that the primary sources of nutrients for these animals must have been different. This problem has so far received little attention." Concluding the paragraph the author then speculates further that planktonic photosynthesizers must have existed in the lower strata but didn't "secrete mineralized shells or tough cellulose coverings" [McAlester AL. 1977. The history of life. 2d ed. Englewood Cliffs, NJ: Prentice-Hall, p 58].

For three decades at least, science has known of eukaryotic green algae from the Precambrian Bitter Springs formation of Australia. There, preservation is so perfect that photomicrographs of the sequence of individual cell division have been published. Shouldn't science have long since been able to document the presumably abundant plant food that formed the foundation for the Devonian fish food chain?

If one does not feel obligated to accept the hyperbolic ages attached to the strata, it is then easy to acknowledge that science has already documented the missing Devonian fish food. There it is, upstairs, in the Jurassic!

Richard Kutsch  
Florence, Oregon

# ARTICLES

## COMPATIBILITY OF BIBLICAL CHRONOLOGY WITH C-14 AGE

R. H. Brown  
*Yucaipa, California*

### WHAT THIS ARTICLE IS ABOUT

*The essential agreement between C-14 age and real time over the past 3000-3500 years is readily accounted for by the equilibrium inventory of C-14 that can be expected to have been established in the Upper Biosphere within 1000-2000 years after the Genesis Flood. With continuation of the present circumstances, the Lower Biosphere (ocean below ~300 ft and associated sediment) cannot be expected to reach equilibrium status for C-14 until more than 20,000 years into the future, but there is a reasonable model for accumulation of the present total biosphere C-14 inventory within 5000 years since the flood. Tree ring calibration of C-14 age data beyond 1500 BC presents a challenge of faith for a choice between a biosphere model that accommodates the chronological data in the Bible and one that has been developed without such restriction.*

*This article corrects deficiencies in previous treatments of C-14 dating by the author due to failure to recognize that published estimates for the formation of C-14 are usually based on the assumption that the total biosphere is in equilibrium (infinite age condition) for C-14. And it incorporates some recently published data that are significant for placing C-14 age data within a biblical time frame.*

### INTRODUCTION

For over 40 years C-14 age data have been widely recognized as a major challenge to a chronological framework that accommodates the historical data in Genesis and Exodus. Much dedicated effort has been expended in the search for a biosphere model that satisfactorily incorporates both the available data concerning C-14 inventory and the chronological constraints derived from a straightforward historical-grammatical exegesis of the Bible.<sup>1</sup>

As one who has experienced limited satisfaction and also frustration in this effort, I offer the following as an additional contribution toward a satisfactory treatment of the C-14 age problem in biblical creationism. At the outset I must express my conviction that no treatment of C-14 age can establish the validity of the historical details in the Bible. Evidence for the validity of those details must be accessible to individuals who know nothing about C-14 and the sciences involved in C-14 dating. Our goal is a scientifically acceptable explanation/interpretation of C-14 data from the perspective of the Bible record.

Such explanation/interpretation must deal with three basic considerations.

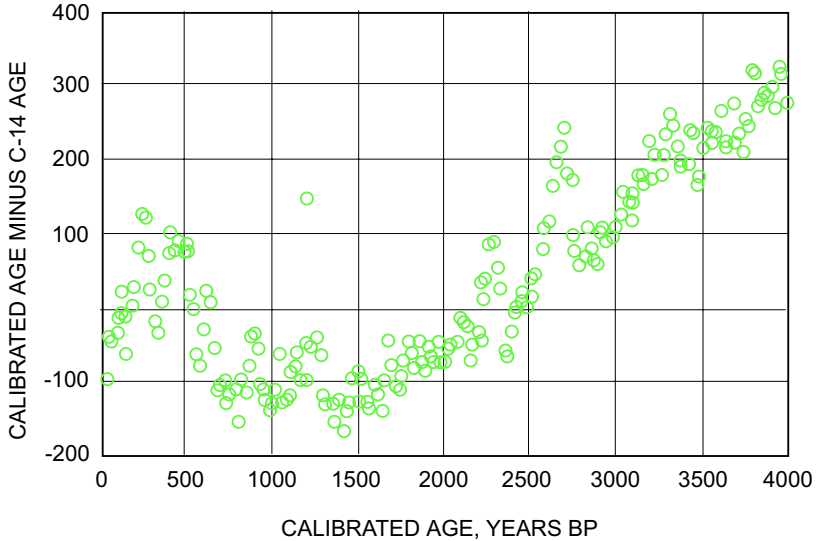
1. The average agreement between C-14 age and unquestioned real time age within about  $\pm 100$  years over the past 3000 years (see Figure 1).
2. The current inventory of C-14 in the world's carbon exchange system — the combination of upper and lower biosphere.
3. The dendrochronological calibration of C-14 ages extending to ~8000 years<sup>2</sup> (and recently extended to ~22,000 years by U-Th disequilibrium dating<sup>4</sup>).

#### **AGREEMENT OF C-14 AGE WITH REAL-TIME AGE**

Figure 1 is a plot of the difference between dendrochronological (tree ring) calibrated age and the corresponding C-14 age over the range between 10 BP (years before present) and 3999 BP, as given in the latest Calibration Issue of *Radiocarbon*. The zero reference for the BP scale is 1950 AD. Accordingly 1950 BP corresponds to 0 BC/AD. The data in Figure 1 relate to the Upper Biosphere — air, soil, surface water, mixed surface layer of the ocean, plant and animal life in this region, and organic residuum which shares in an active interchange of carbon within the region. The actual variations of the C-14/C-12 ratio in the Upper Biosphere have been less than might be expected from the impression given by Figure 1. The highest and lowest points between 0 and 3000 BP represent, respectively, only +2.1% (2699 BP) and -2.5% (1420 BP) difference between the age-corrected C-14/C-12 ratio in the sample and the carbon isotope ratio standard reference. (The carbon isotope standard reference is indicated by line A in Figure 4.)

The validity of the tree-ring master sequences on which the data for Figure 1 is based is controlled by the availability of material which





**FIGURE 1. Dendrochronological calibration of C-14 age. Ordinates are the number of years that must be added to a C-14 age to obtain its associated tree-ring calibrated age, as specified on the abscissa. Data from References 2 and 3. BC/AD division is at 1950 BP.**

can be C-14 dated and also has an unquestioned historical age. The time range from which such samples are available extends to the vicinity of 3500 BP (~1500 BC).<sup>5</sup> The essential agreement between C-14 age and real time over this time range indicates an approximately constant C-14/C-12 ratio in the reservoir from which the samples for C-14 dating have been obtained. In other words, the Upper Biosphere has been in essential equilibrium (equal C-14 input and output rates) over at least the past 3500 years.

C-14 enters the Upper Biosphere by diffusion and turbulence mixing from the stratosphere where it is produced by cosmic radiation.<sup>5</sup> Some C-14 is eliminated from the Upper Biosphere by radioactive conversion to Nitrogen-14, but most output is by transfer from the Mixed Surface Layer of the ocean to the Deep Ocean. Most of the C-14 inventory is known to be in the Deep Ocean. The mean life of C-14 atoms before conversion to N-14 is 8245 years,<sup>6</sup> but the mean life of C-14 atoms in the Upper Biosphere is only ~375 years. The 375-year estimate has been obtained from analysis of changes in C-14/C-12 ratios resulting from nuclear weapon tests.<sup>7</sup>

When some entity is introduced into a reservoir at a constant rate  $R$ , and has a mean life  $\tau$  in that reservoir, the quantity  $q$  of this entity at any time  $t$  after initial startup with  $q = 0$  at  $t = 0$  is given by the exponential equation

$$q = Q (1 - e^{-t/\tau}) \quad (1)$$

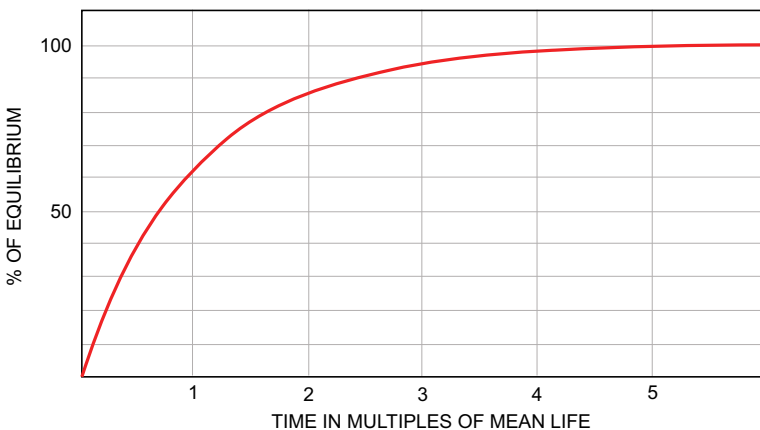
in which  $e$  is the base of the natural logarithms, and  $Q$  represents the equilibrium value of the entity represented by  $q$ . At equilibrium  $Q = R\tau$ , and

$$R = Q (1/\tau). \quad (2)$$

Ideally equilibrium is not attained until  $t$  becomes infinite, making the last term in Equation (1) zero. For practical consideration,  $q = 0.99Q$  when  $t = 4.6\tau$ . At  $t = 3\tau$ ,  $q$  has reached 95% of its equilibrium value. These relationships are illustrated in Figure 2.

From these simple considerations one can conclude that if the Upper Biosphere had a relatively insignificant C-14 concentration immediately after the flood (Genesis 6-8), with  $\sim 375$  years mean residence time C-14 in the Upper Biosphere would reach 95% of equilibrium concentration by  $\sim 1125 (=3 \times 375)$  years after the flood. Practically complete equilibrium would be attained in  $\sim 1725$  years. Placing the flood at 5350 BP (3400 BC), according to the numerical data values in the Bible

**FIGURE 2. Exponential growth of a radioisotope at constant rate of formation. Ordinates are percentage of equilibrium level. Equilibrium level  $Q$  is equal to the product of the formation rate  $R$  and the mean lifetime  $t$ . Abscissae are time as the number of mean lifetimes.**



used by the New Testament church (the Septuagint),<sup>8</sup> essential equilibrium of C-14 in the Upper Biosphere would have been established by 1675-2275 BC. The relatively small variations in the Upper Biosphere C-14/C-12 ratio (differences in C-14 age with respect to real-time age) since 1500 BC are readily accounted for in terms of variation in the cosmic radiation shield provided by the magnetic fields of the Earth and the Sun, and in the cosmic-ray particles emitted by the Sun.<sup>9,10</sup>

The foregoing treatment indicates that if the generation rate of C-14 by cosmic ray interaction in the stratosphere, and the mean residence time of C-14 atoms in the Upper Biosphere have been relatively constant since the flood, C-14 ages should be in close agreement with corresponding real-time age over at least the past 3000 years, as required by Consideration #1, and depicted in Figure 4C.

### C-14 INVENTORY ACCUMULATION

Consideration #2 presents greater difficulty.

Fossil organic material (petroleum, coal, wood, shells, bone) from geological horizons that reasonably must be interpreted as indicative of burial in the Genesis flood episode, and is not a component of the modern biosphere, has less than 2% of the modern concentration of C-14 in the Upper Biosphere.<sup>11</sup>

Estimates of the amounts of carbon in the various regions of the biosphere, combined with measurements of the C-14/C-12 ratio in these regions, have produced estimates of the modern C-14 inventory typically in the range between ~50,000 kg<sup>12</sup> and ~75,000 kg.<sup>13</sup> At the estimated C-14 production rates that have been published in the scientific literature, e.g., 8.0 kg/yr in a recent publication,<sup>14</sup> the “observed” C-14 inventory could not have been established by 5400 years after the flood. At 8.0 kg/yr formation rate and 8245 years mean lifetime, Equations (1) and (2) specify

$$q = 8.0 \times 8245 (1 - e^{-5400/8245}) = 65,960 \times 0.48 = 31,696 \text{ kg}$$

for the biosphere, only 48% of a 66,000 kg equilibrium inventory (rounding 65,960 to 66,000).

In an effort to account for the biosphere C-14 inventory, I have proposed that during the early centuries following the flood C-14 was produced much more rapidly than at present (e.g., see Reference 15). This approach may be rendered unnecessary by recognizing that the formation rates usually cited in the literature are based on the *assumption*

that the biosphere is in C-14 equilibrium, and the additional assumption that the effective C-14 formation rate may be correctly estimated as the quotient of the present inventory value and the mean life of C-14 atoms (Equation 2). The 8.0 kg/yr production rate noted in the preceding paragraph is based on the assumption that a present inventory of 66,000 kg represents equilibrium ( $66,000/8245 = \sim 8.0$ ).

A first-order approximation model that is consistent with the biblical data and the C-14 content of fossils from burial in the flood (less than 2% of the present biosphere level) should specify that the total biosphere at present has reached only about half (48% in the example immediately above) the C-14 equilibrium level. Ninety-five percent of equilibrium level would not be reached until about 26,000 ( $=3 \times 8245$ ) years after the flood. An appropriate estimate of the C-14 formation rate for such a model should not be based on an assumption that present circumstances represent equilibrium.

A recent geophysics and climatology group investigation of the distribution of C-14 produced by nuclear weapon tests indicates that previous estimates of the amount of C-14 in the Lower Biosphere (deep ocean and sediments) have been excessive.<sup>7</sup> As shown in Table 1 (row 1, columns 1 and 2) their estimate of the C-14 formation rate at 5.35 kg/yr is associated with a 44,100 kg estimate for the equilibrium inventory in the total biosphere ( $44,100/8245 = 5.35$ ).

Significant data that must be taken into account in the development of a model for relating C-14 age to biblical chronology are given in Table 1.

A good estimate for the C-14 inventory in the contemporary Upper Biosphere is 5599 kg.<sup>16</sup> Since the other data in Table 1 are based on estimates that might be classed as educated guesses (uncertainties as great as  $\sim \pm 20\%$  are specified in the original publications), 5600 kg is a suitable figure for column 3 of Table 1, and all data in this table should be considered uncertain within at least  $\pm 20\%$ . With the uncertainty in determining the precise time since the flood from biblical specifications, 5000 years may be used as a satisfactorily approximate specification for this time, as determined from the Septuagint text. The last column specifies the C-14 accumulation in 5000 years (45.5% of equilibrium level) at the rate given in the corresponding row of the first column.

Column 4 lists Column 2 minus 5600, and column 5 minus 5600. Column 4 indicates the amount of the world inventory of C-14 that must be accounted for in the Deep Ocean and its related sediments.

**TABLE 1: BIOSPHERE C-14 MODELS**

<b>Formation Rate (kg/yr)</b>	<b>Equilibrium Inventory (kg)</b>	<b>Upper Biosphere Contemporary Estimate (kg)</b>	<b>Deep Ocean plus Sediment (see note§) (kg)</b>	<b>5000 yr Accumulation (kg)</b>
5.35†	44,100	5,600	38,500/14,400	20,000
5.9†	48,600	5,600	43,000/16,500	22,100
8.9†	73,400	5,600	67,800/27,800	33,400
10.20	84,400*	5,600	78,800/32,800	38,400
11.90	97,000	5,600	91,400/38,500	44,100

§ (at equilibrium)/(at 5000 yr)

† Formation rate for estimated equilibrium inventory (based on data in References 7, 12, and 13)

\* Equilibrium inventory for estimated formation rate from Reference 9

Last (italicized) row is suggested data for biblical time-scale model based on 44,100 kg estimate of contemporary biosphere inventory from Heshalmer et al. (1994)

Rows 2 and 3 give the range of typical data published prior to 1994

Uncertainty of estimates is at least ±20%

The data in row 4 are based on a C-14 formation rate estimate obtained from data for cosmic ray intensity and geomagnetic field strength (Reference 10, Table V; kg/yr =  $3.74 \times \text{atoms/cm}^2/\text{sec}$ ), and do not involve an uncertain assumption as to whether the biosphere is or is not in equilibrium for C-14. For individuals who model the biosphere on the basis of presumed equilibrium and unrestricted time, a C-14 formation rate derived from an estimate of the equilibrium inventory is as significant as one derived from estimates of factors associated with the primary production process. For a model that specifies nonequilibrium, the only suitable C-14 formation rate estimate must be based on nuclear reaction probabilities, cosmic ray intensity, and magnetic field considerations.

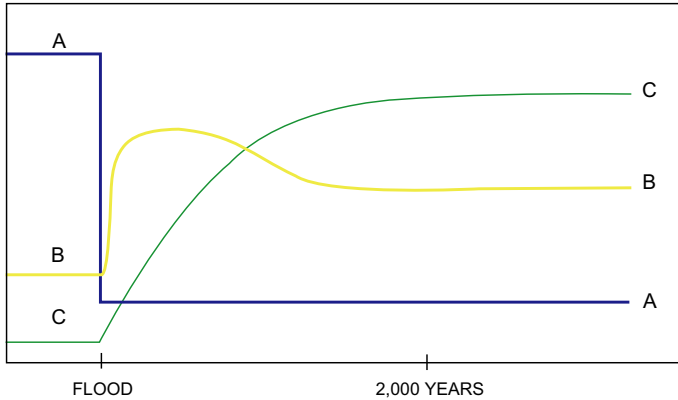
The last row of Table 1 represents a biosphere C-14 exchange system model that incorporates the chronological limitations obtained from the Bible. It is based on the latest (1994) published estimate of the biosphere inventory (44,100 kg from Reference 7), considered as a 5000-year accumulation, rather than as an equilibrium state. (Compare row 1, column 2 with row 5, column 5.) This model requires an effective average C-14 formation rate that is within a ±20% uncertainty range of the best estimate based on cosmic ray intensity and geomagnetic field strength.

Taking extreme values for a  $\pm 20\%$  uncertainty, Equations (1) and (2) with a present inventory of  $1.2 \times 44,100$  kg (from line 5, column 5), a formation rate of  $0.8 \times 10.2$  kg/yr (from line 4, column 1), and  $\tau = 8245$  years, specify 12,734 years for buildup from a zero kg start to the postulated present inventory. With these assumptions, particularly zero initial inventory, one can place  $\sim 13,000$  years as the maximum “real time” range that can be covered by C-14 age determinations.

To close the gap between the 11.9 and 10.2 kg/yr C-14 formation rates on lines 5 and 4 of Table 1, a more complex model could allow for possible higher cosmic ray intensity and/or lower geomagnetic field strength, with associated higher C-14 production rate, within the first two millennia following the flood. This model would require a lower production rate over the last 3500 years in order to produce the C-14 accumulation associated with the 12 kg/yr average specified in row 5. An initially higher production rate is reasonable in view of the cosmogenic nuclide (particularly Beryllium-10) concentrations in ice cores from Greenland, and sediment cores from the ocean, which indicate that at the height of the Ice Age C-14 production was at least 25% higher than at present<sup>17</sup> (greater Be-10 concentration per unit volume of ice in a thin section of ice core), and  $\sim 20\%$  higher at the end of the Ice Age ( $\sim 10,000$  BP C-14 age).<sup>18</sup>

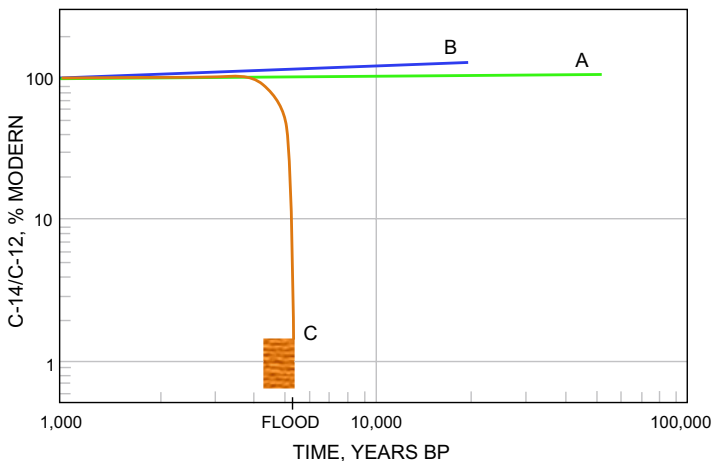
Hence at this stage in the development of a model for the C-14 exchange system a transiently higher C-14 formation rate may be postulated for the early centuries following the flood, as depicted by Line B of Figure 3. With such specification the requirement for a  $\sim 12$  kg/yr average could be met with a modern formation rate closer to the 10 kg/yr estimate based on cosmic ray and geomagnetic field intensities. The initial portion of Line B represents the possibility that in order to provide greater protection of organisms from cosmic ray damage, the geomagnetic field prior to the flood was stronger than it has been over the last 3000 years. Line B of Figure 3 has been drawn only to indicate possible change, and not to designate magnitudes or rates of change.

Line A — total biosphere carbon — in Figure 3 represents the transfer of a large portion of the carbon inventory from the active exchange system to a fossil state (coal, petroleum, fossil shell and bone, e.g.) at the time of the flood. The trends depicted in Figure 3 for transition from pre-flood to modern conditions accommodate both the first and second considerations specified previously on p 67.



**FIGURE 3. Biosphere Transition.** Ordinates indicate suggested trends only, and are arbitrary for both magnitude and scale. A: Total Active Biosphere Carbon. B: C-14 Formation Rate. C: Upper Biosphere C-14/C-12. Upper Biosphere equilibrium is presumed to have been essentially established by 2000 yrs after the flood.

**FIGURE 4. Upper Biosphere C-14/C-12 Ratio vs Time BP.** Ordinates are first approximation of C-14/C-12 ratio as percent of the modern reference value. A: C-14 age based on equilibrium throughout all past time. B: C-14 age calibrated by tree rings and coral. C: C-14 age calibrated by biblical chronology. Above (below) 100% ratio C-14 ages are less (greater) than corresponding real-time age (see text). Concerning the range of uncertainty for BP date of the flood and C-14/C-12 ratio at the time of the flood, see References 8 and 11.



## DENDROCHRONOLOGICAL CALIBRATION OF C-14 AGE

Master tree-ring sequences have been constructed for bristlecone pine in the USA, and for oak and pine in Northern Europe. When extrapolated beyond the range for which unquestioned historical records control the selection of ring overlap between wood specimens, these sequences indicate that conventional C-14 ages at ~10,000 BP are ~10% less than the corresponding real-time age as estimated by dendrochronology.<sup>2</sup> Recent dating of Barbados coral by both C-14 and uranium-thorium series disequilibrium techniques has extended this discrepancy to ~20% at 20,000 BP.<sup>4</sup> These extrapolations are represented by Line B in Figure 4. (A C-14/C-12 ratio *greater* than the ratio on which C-14 ages are based — ratio greater than 100% — represents a C-14 age *less* than the corresponding “real time” age.) Their near-universal acceptance in scholarly circles presents a major challenge to a chronological framework based on the Bible. As represented by Line B, C-14 ages beyond ~1500 BC are progressively *less* than the corresponding “real-time” age. As represented by Line C, they are progressively much *greater* than the corresponding “real-time” age.

The extension from coral dating can be questioned on the basis that U-Th disequilibrium dating is based on the assumption that uranium and thorium isotope ratios in seawater have always been the same as at present.<sup>19</sup> Volcanism and contact with fresh exposures of mineral surfaces during the crustal breakup associated with the flood, and during continental relocation that probably occurred in early post-flood time, would be expected to temporarily modify the traces of radioisotopes in seawater. If there has been a transition to modern isotope ratios, U-Th disequilibrium “ages” would have an unknown relationship with real time.

Some biblical creationists have tried to resolve the difficulty associated with a sequence of as much as 8000 tree rings by suggesting that trees produced multiple growth rings per year over several centuries following the flood. There may have been many years in which more than one growth ring was produced at some locations, but the production of as many as 4000 false “annual” rings over only 1500, or at most 2000, years is not a scientifically well-founded expectation. Extensive research beyond what has been attempted so far would be required to find any support that might exist for this suggestion.



The intellectual climate in which tree-ring master sequences have been constructed favored selection of the longest sequence that could be justified. The use of C-14 ages to roughly sequence a set of wood samples before “fine tuning” by ring matching favored development of a master ring sequence that relates C-14 age to real-time age on an approximate 1:1 basis, i.e., extension of the master dendrochronology scale to about 8000 years, rather than the limit of ~5000 years to be expected from biblical specifications. Individuals who include biblical testimony in their data base would seek wood sample growth-ring overlaps that could be justified on a sound biological basis without recourse to C-14 dating and also produced a minimal sequence. Given the subjective aspect of tree-ring sequence matching, there is a possibility that a master sequence developed from a biblical perspective would have a mathematical correlation coefficient equally good, if not better, than do the master sequences that have become the current standard for C-14 age calibration.

At least until someone with adequate qualifications attempts to develop a 5000-year-limited master tree-ring sequence, the current dendrochronologic calibration of C-14 ages will be a major test of faith for individuals who adhere to straightforward historical-grammatical exegesis of the Bible. This is not blind faith, because there are C-14 data that are incongruous on the basis of Curve B in Figure 4, but have clear significance when interpreted in accord with Curve C. Examples of such data are given in References 11 and 15.

### **CONCLUDING COMMENT**

In full perspective there is a basis for confidence, and also room for doubt, regarding compatibility between C-14 age data and the chronological data in the Bible. For most individuals, selection between these options will be influenced by predilection, rather than a decision based merely on the weight of evidence.

### **ACKNOWLEDGMENT**

The author wishes to express appreciation for the suggestions from unnamed pre-publication reviewers of this manuscript. The reader can thank them for many improvements in readability and technical clarity.

## APPENDIX I

While Figure 1 indicates that the C-14/C-12 ratio in the Upper Biosphere has been approximately constant over the past 3000 years, it raises questions concerning the trend for negative correction to C-14 age in the 0-200 and the 600-2400 year ranges. These trends are much greater than the minor variations due to the 11-year cyclic pattern of cosmic ray output from the Sun.

The zero age reference for C-14 dating is the C-14/C-12 ratio that would be expected in the Upper Biosphere *if* there had been no “contamination” by carbon from the use of fossil fuels. Since fossil fuel (coal, petroleum, and natural gas) contains  $\leq 1\%$  of the C-14/C-12 ratio that characterizes the modern situation, the use of fossil fuel *adds* to C-12 and *reduces* the C-14/C-12 ratio in the Upper Biosphere.

Plants and animals grown since the beginning of the Industrial Revolution would at their zero age have had a *lower* C-14/C-12 ratio than the reference C-14/C-12 ratio on which C-14 dating is based. Hence their C-14 age at present will be *greater* than it would have been if there had been an insignificant use of fossil fuel. This difference will be proportional to the accumulated consumption of fossil fuel,<sup>20</sup> as indicated by the left-most portion of Figure 1.

The negative correlation trend in the 600-2400 year range correlates with long-term changes in the geomagnetic field.

C-14 production is inversely related to geomagnetic field intensity, since the geomagnetic field deflects the primary cosmic rays, reducing the portion that interacts with the stratosphere to form C-14. Direct measurements of the geomagnetic field intensity over the time such capability has existed indicate that there has been a steadily *decreasing* trend over the last 150 years. The remnant magnetism in sediments and volcanic formations indicates that over an extended period prior to 2000 BP the geomagnetic field intensity was *increasing*. Over the range from  $\sim 500$  BP to  $\sim 3500$  BP the geomagnetic intensity has been *greater* than it was at the beginning of the Industrial Revolution.<sup>21</sup> A *greater* geomagnetic field intensity correlates with *lower* C-14 production, a *lower* C-14/C-12 ratio in the biosphere, and C-14 ages *greater* than would have been the case if the geomagnetic field had remained constant.

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# ANNOTATIONS FROM THE LITERATURE

## GENETICS

Wilson R, et al. (55 authors). 1994. 2.2 Mb of contiguous nucleotide sequence from chromosome III of *C. elegans*. Nature 368:32-38.

**Summary.** The small, free-living roundworm, *Caenorhabditis elegans*, has a genome of about 100 million base pairs. An attempt is underway to sequence the entire genome of this worm. The DNA sequence reported, about 2% of the genome, is one of the largest contiguous DNA sequences known. Perhaps unsurprisingly, the data has revealed some surprises.

First, genes are more numerous than expected. On average, one gene was found for about every 5000 base pairs. Assuming this is characteristic of the entire genome, the total number of genes in the genome is estimated at nearly 18,000. Second, a much higher than expected proportion of the genome is involved in coding. Putative coding sequences account for 29% of the sequenced genome. When introns are included, the total rises to 48%. This is perhaps ten times the proportion previously estimated as typical. Third, the number of genes not shared with other phyla appears to be larger than previously thought. The authors estimate that at least 60% of the genes are unique to roundworms. Fourth, inverted repeats are the most common type of repeat, and are located in introns twice as frequently as in other parts of the genome. Most of the inverted repeats have characteristics that suggest they may be remnants of mobile elements. By contrast, most tandem repeats were located between genes. Fifth, some sequences with 98% similarity are found widely separated on the chromosome. These might be duplicated genes, but how they became so widely separated is not clear.

**Comment.** This report, together with advances in other genome studies, demonstrates that we still have a great deal to learn about how the genome operates.

## GEOLOGY

Acton GD, Gordon RG. 1994. Paleomagnetic tests of Pacific Plate reconstructions and implications for motion between hotspots. *Science* 263:1246-1254.

*Summary.* The chain of islands and seamounts terminating with the Hawaiian Islands is thought to have been produced by an upwelling of magma from the mantle, known as a “hotspot.” The hotspot is thought to be stationary, producing a chain of islands as the Pacific Plate moves over it. It is thought that Earth’s plates are driven by slow motion of the mantle. One might wonder how the mantle can move enough to cause plate motion while allowing the hotspots in the mantle to remain fixed in position. It now appears that hotspots may not have been entirely stationary, but have also been moving.

*Comment.* Estimates of the past locations of Earth’s poles and tectonic plates have generally relied on the assumption of fixed-position hotspots. This means that plate reconstructions for the lower Tertiary may need adjustment, by an amount estimated to be approximately 500 to 1000 km.

Lowe DR. 1994. Abiological origin of described stromatolites older than 3.2 Ga. *Geology* 22:387-390.

*Summary.* Stromatolites are laminated sedimentological features produced by surface concentrations of bacteria or algae. Three examples of stromatolites with supposed ages of more than 3.2 billion years have been reported and widely accepted. However, fossil bacteria have not been found associated with any of them. This paper reports that none of these “stromatolites” are biological in origin. Of the two occurrences in Western Australia, one is interpreted as produced by evaporitic precipitation and the other as soft-sediment deformation. The third example, from South Africa, is interpreted as produced by inorganic precipitation.

## MOLECULAR EVOLUTION

McKenzie JA, Batterham P. 1994. The genetic, molecular and phenotypic consequences of selection for insecticide resistance. *Trends in Evolution and Ecology* 9:166-169.

**Summary.** Development of pesticide resistance in insects is an interesting example of rapid genetic change. The discovery that DDT resistance in *Drosophila* had a polygenic basis led to the inference that resistance in most insect populations had a polygenic basis. However, pesticide resistance in most natural populations involves only one or two genes. This makes the study of pesticide resistance easier than first thought.

Several different mechanisms may operate to produce pesticide resistance. Among these are increased cuticular thickness (which reduces penetration of the pesticide), chemical detoxification, target-site modification, increased excretion, and behavioral avoidance. Combinations of these mechanisms may provide the polygenic basis of resistance. Similar responses to the same pesticide are frequently observed in different populations or species.

In one studied example of resistance of *Culex* (mosquito) to an organophosphate, gene amplification of an esterase was the mechanism by which resistance was achieved. Amplification was at least 250-fold. Migration of the resulting resistant strain was deemed more significant than the rate of mutation. In another studied example of resistance of *Drosophila* to dieldrin, a single amino acid substitution was discovered in a chloride channel pore, reducing the binding of dieldrin. Amino acid substitution at the same site is believed to explain resistance in three different insect orders, although the exact substitution is not identical in all cases. Certain carboxylesterases mediate resistance to diazinon and malathion. The ordinary function of these enzymes is not yet well understood. Insect resistance appears to be based on undirected mutations, rather than to be environmentally induced. It appears that these mutations often may be small changes in amino acid sequence or gene regulation.

**Comment.** The rapid development of insect resistance to pesticides illustrates the point that genetic change may be rapid. This point may help to explain how such a large number of species could be produced in a relatively short time. Another point illustrated is that much genetic change is decoupled from morphological change.

## PALEONTOLOGY

Bowring SA, Grotzinger JP, Isachsen CE, Knoll AH, Pelechaty SM, Kolosov P. 1993. Calibrating rates of Early Cambrian evolution. *Science* 261:1293-1298.

**Summary.** Cambrian rocks contain the first abundant record of shelly fossils. The sudden appearance of a large diversity of fossils within a relatively small portion of the geologic column has been referred to as the “Cambrian explosion.” Most extant phyla and classes of animals appear in Cambrian sediments. The standard interpretation of the Cambrian system has supposed that it extended from 570-510 million years ago, with most of the “explosion” having occurred between 570 and 554 million years ago. The appearance of so many new body types in only 16 million years has been much discussed in the literature. New radiometric dates are now interpreted as indicating the period of time was even shorter. Zircon crystals taken from rocks at the base of the Cambrian in Siberia gave uranium-lead dates of 544 million years. Revised dates suggest the “Cambrian explosion” occurred within a supposed period of 5-10 million years.

**Comment.** The sudden appearance of a diversity of higher taxa, each represented by a small number of species, seems to be a common feature of the fossil record. If diversity were produced by evolutionary change, one would expect to see first a higher diversity of species within a small number of higher taxa, followed by stepwise addition of additional higher taxa. The observed pattern of diversity seems more consistent with the pattern expected from a catastrophic mass mortality event than from a record of gradual evolutionary change.



## LITERATURE REVIEWS

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### BONE PICKING

**BONES OF CONTENTION: CREATIONIST ASSESSMENT OF HUMAN FOSSILS.** M.L. Lubenow. 1992. Grand Rapids, MI: Baker Book House Co. 295 p. Paper, \$12.99.

*Reviewed by Earl Aagaard, Biology Department,  
Pacific Union College, Angwin, California*

*The human fossil record is strongly supportive of the concept of Special Creation. On the other hand, the fossil evidence is so contrary to human evolution as to effectively falsify the idea that humans evolved.*

So begins the preface to this fascinating (and thoroughly referenced) book, which challenges much that most of us have believed about paleoanthropology, while confirming some things that we have only suspected. Lubenow is on the conservative end of the creationist spectrum, and his purpose for the book is to:

*... demonstrate that even when the human fossils are placed on time charts according to the evolutionist's dates for these fossils, the results do not support human evolution but conflict with it.*

The book serves as an extremely accessible introduction to the field of paleoanthropology, with terms and concepts defined, the important fossils placed in historical and taxonomic context, and scientists identified and associated with their respective institutions. The problem of the radiometric dating methods are dealt with in an appendix, where the story of the 10-year attempt to fix the proper date on Richard Leakey's KNM-ER 1470 is told.

After several chapters of introduction, Lubenow dedicates chapters to Neanderthal man, to archaic *Homo sapiens*, and seven chapters to

*Homo erectus*, which he considers “the key to the proper understanding of the human fossil material.” In Chapter 16 he then synthesizes his arguments, using the “most comprehensive human fossil charts to be found anywhere in the scientific literature.” What Lubenow does is to put species on the X axis and radiometric time on the Y axis. He then lists the known fossils from each species at the proper time level. Doing this reveals that anatomically modern *Homo-sapiens*-like fossils coexist with *Homo erectus*, *Homo habilis*, and at least two species of *Australopithecus*. Perhaps his most electrifying claim is that anatomically modern humans existed at 4.4 million radiometric years, but he substantiates this from the literature.

A full chapter is devoted to explaining why Christians should be interested in human origins. His vehicle is the Baby Fae story. Then comes a chapter on the Big-Bang and its relevance to the question of human origins, followed by a fascinating “proof” of an early date for Genesis, with Moses as redactor or editor. The early date is held by conservative Christians in contrast to a later date for the view that Genesis is a compilation of tradition. I would like to see someone with appropriate expertise respond to this chapter. Finally, in his last chapter Lubenow deals kindly but firmly with fellow Christians who adopt a non-literal view of Genesis.

The book ends with a major appendix on radioactive dating, 20 pages of endnotes arranged by chapter, and three indices: of persons, fossils, and topics. This book should be read and re-read by everyone interested in being informed on the subject of paleoanthropology.

## LITERATURE REVIEWS

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### WHO ARE THE CREATIONISTS?

THE CREATIONISTS: THE EVOLUTION OF SCIENTIFIC CREATIONISM. R. L. Numbers. 1992. NY: Alfred A. Knopf. 458 p. Hardcover, \$27.50.

*Reviewed by Jerry Bergman, Biology, Chemistry, Physics,  
Northwestern State College, Archbold, Ohio*

Today there exists much misunderstanding about the creation movement. Fortunately, Ronald L. Numbers has produced an extremely useful work which goes a long way toward dispelling many of the commonly accepted myths. One frustrating aspect of the book — which tends to be the norm in works on creationism — is that the author never formally defined such critical terms as creation, evolution, fundamentalism, and even science. A typical definition of a creationist has been given by Thomas Jukes (1991), who concludes that:

*Creation science is based on dogma that creation took place about 10,000 years ago, that the book of Genesis supplies scientific description of what followed, including the Garden of Eden, ... existence of humans and dinosaurs, presence of dinosaurs on Noah's Ark, variability in the speed of light to account for the 10,000-year-old universe, and the denial that radioactive decay is at constant rate. Separate ancestry for humans and apes is, of course, essential to creationism.... Disbelievers in creationism 'must ultimately be consigned to the everlasting fire prepared for the devil and his angels.' ... This imprecation is a form of psychological terrorism that would be inflicted upon schoolchildren if creationists had their way.*

The trouble with this definition is that almost none of the creationists discussed by Numbers believe much or even most of it. As Numbers

states, “By the late nineteenth century even the most conservative Christian apologists readily conceded that the Bible allowed for an ancient earth and pre-Edenic life” (p x). Even Henry Rimmer, the “flamboyant evangelist” and most conservative forerunner of the modern creation movement, did not accept much of this definition. Rimmer, who occupied center stage of the most fundamentalist wing of the creationist platform between the two world wars, “squeezed millions of years into the presumed gap in the Genesis narrative and drained the deluge story of all but local significance” (p x). When the Creation Research Society (CRS) was formed, it was difficult to locate even creation scientists who accepted the young-earth/young-universe position, a point which Numbers emphasizes at length.

Numbers shows that many of the naturalists in the late 1800s were creationists in the broad sense in that they accepted God as the creator and also accepted some evolutionary change as do nearly all creationists involved in science today. He also concludes that most scientists, even evolutionists who did not fall into the creation camp, “remained skeptical about the primacy of natural selection in the evolutionary process” (p 5). They instead emphasized such factors as “the inheritance of environmentally induced characteristics” (p 5).

Numbers also briefly documents the conversion of many eminent American scientists to some form of theistic evolution, noting that stalwarts such as James Dana, the country’s best-known geologist, experienced only a “lukewarm conversion to evolution” while still clinging “to the conviction that a special creative act had introduced the first humans” (p 7). Numbers also shows that, in contrast to today, many of the early American scientists — such as botanists Asa Gray and Louis Agassiz — were religiously orthodox. Numbers admits that “one of Darwin’s principal goals was ‘to overthrow the dogma of separate creations’” and adds that Darwin also admitted, “‘however much we may wish it, we can hardly follow Professor Asa Gray in his beliefs’ in divinely guided evolution” (p 4). Frederick Wright of Oberlin College is probably the best example of many (and one of the most extensively discussed) who belied the common assertion that creationists are rigid, true believers, fenced in by a straitjacket of biblical literalism with fundamentalist blinders. Indeed, many scientists then struggled with faith-and-science issues throughout their lives, and their positions were not always crystallized. Sometimes, as in the case of

Wright, their beliefs apparently underwent radical change and were partly contradictory.

It is also often assumed that the primary objections to evolution were biblical. As Numbers clearly documents, many of the objections were far more than this.

*[The] most famous creationist of all, Agassiz, simply ignored the biblical record. Guyot, Dawson, Burr, Armstrong, and Hodge as well as Dana before his conversion cherished the Bible as God's inspired word but were willing nevertheless ... to adopt a figurative reading of the first chapter of Genesis (p 17).*

Summing up the late 1800s, Numbers' conclusion agrees very much with my own, namely, that "the intellectual differences between creationists and evolutionists were not always as great as one might assume" (p 11). Indeed, it is exceedingly difficult to classify scientists who lived in this and later periods in a creation-evolution dichotomy, and about the only meaningful division is between the outspoken atheist agnostic category and everyone else. According to one study quoted by Numbers, a "sizable minority" of the Protestant contributors to religious quarterlies rejected the theory of organic evolution, showing that it was by no means a concern only of fundamentalists, as is often assumed (p 13).

According to Numbers, another reason why so many of a religious persuasion — including religious scientists as well as the clergy — were critical of evolution was because of the "turn-of-the-century debates within the scientific community over the validity of Darwinism"; that "by the late nineteenth century many were expressing skepticism about the ability of Darwin's theory of natural selection to account for the origin of species" (p 37-38), a debate not unlike those still in progress today. Numbers documents primarily the rise of a revised creationism in the late 1880s and again in the 1960s which were fueled in part by "the aggressive declarations" of "biologists, who announced their determination to drive the last vestiges of supernaturalism from science," a campaign which "aroused fear and anger among the orthodox" (p 37).

The book is full of historical insights which connect a number of prominent Christians with the creation movement — the apologist C.S. Lewis found the "arguments against evolution increasingly

compelling — and the pretensions of many biologists repellent,” and he even wrote that evolution may be “*the* central and radical lie in the whole web of falsehood that now governs our lives” (p 153). Numbers debunks the often-cited belief that members of the larger scientific community scrupulously “‘ferret out deception’ and punish offenders,” whereas creation scientists are “‘unwilling to punish systematic deception in their very midst.’” According to Numbers, the above comment is inaccurate because the abuses by creationists are “less prevalent” than this conclusion implies, and “some of the most telling criticisms of creation science have come from creationists themselves and have appeared in their own journals” (p 258).

This reviewer’s major concern is where Numbers discusses the area closest to my research, i.e., discrimination against those who are, for whatever reason, labeled creationists. Admittedly, some of the cases that I reviewed were difficult to document, but many had overwhelming documentation of discrimination (Bergman 1984). Although he questions the extent of my conclusion, Numbers eloquently supports my thesis, even acknowledging that his colleagues believe that a creationism worldview is “pathological” (p 342) and that, although some scientists dislike the idea of suppressing dissent, others have “jokingly dismissed creationists as a bunch of pseudoscientists who got ‘their doctorates in a box of Cracker Jacks,’” while many scientists regard the creation worldview as “‘nonsense’ on a par with the concerns of the flat-earth society” (p 319-320).

A major handicap of Numbers’ work is that he was not a part of the creation movement’s inner circle, and consequently had to rely upon the kindness and honesty of creationists in providing letters, interviews and documentation in order to tell his story. Much of their in-fighting and examples of lapses in professionalism did not make it into his work, either because he felt it to be redundant or, most likely, he did not interview creationists who had this information, or those whom he interviewed believed it to be inappropriate to reveal this history to him. Conversely, much of the positive was also not recounted (for an excellent balance to Numbers, see McIver 1989).

The work also contains a well-written, fairly accurate summary of the history of the American Scientific Affiliation (ASA), which minimized its internal conflicts while maximizing its conflicts with other groups. Numbers even covers the ASA’s attempts to enter the

foray with their booklet *Teaching Science in a Climate of Controversy*, which only

*... outraged many evolutionists, who denounced the ASA for promoting creationism in disguise. A cluster of big-name critics writing for The Science Teacher accused the ASA scientists of hiding their intentions under 'the veneer of sweet reasonableness,' of 'telling lies to naïve and trusting young persons,' and of obfuscating, distorting, and waffling 'to the point of pure nonsense' (p. 321-322).*

One noted science writer dismissed the ASA's efforts as nothing but "an ordinary exercise in pseudoscience" which is more dangerous than the CRS brand because it presented "that pseudoscience in a package so slick that it can seem respectable to people who would dismiss an I.C.R. [Institute for Creation Research] tract as ridiculous" (p 322).

Numbers effectively refutes many of the critics of creationism by examining their claims such as "creationists are not scientists" because they have abandoned the scientific attitude. He includes such gems as noting the inconsistency of prominent critics of creationism who first asserted that

*... 'the hypothesis of special creation has, over nearly two centuries, been repeatedly and sympathetically considered and rejected on evidential grounds by qualified observers and experimentalists.' But just four pages later the same writers claimed that special creation was not 'a testable hypothesis for the origin of the universe, the earth, or of life thereon' (p. 248).*

To describe creationism both as having been tested by science, and then being untestable, is not uncommon.

In short, this work is a commendable, basically fair presentation which is only part of the story and requires at least a reading of the prolific works of Henry Morris and Tom McIver's summary of many of the same events in order to obtain a balanced view of the creationists' history. As Numbers himself admits, a number of his reviewers "disagreed vehemently with my interpretation and even some of my 'facts'" (p 348).

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# GENERAL SCIENCE NOTES

## PSEUDOGENES AND ORIGINS\*

By L. J. Gibson, Geoscience Research Institute

### WHAT THIS ARTICLE IS ABOUT

*Pseudogenes are DNA sequences that resemble functional genes but seem to have no purpose. The presence of similar eta globin pseudogenes in humans and chimps has been used as an argument for common ancestry of the two species. The argument has two parts: that the pseudogene sequences actually have no function, and that God would not create similar non-functional sequences in humans and chimps. The latter argument is theological and resembles many other theological arguments that have been proposed and later abandoned. Theological arguments should not be relied on unless well supported by Scripture.*

*The argument that the eta globin pseudogene has no function is consistent with most of the data, although lack of function has not been demonstrated. Possible function is suggested by the location of the pseudogene and differences in the extent of divergence of “intronic” and “exonic” sequences. The possibility that the eta globin pseudogene provides a binding site for a molecule involved in gene regulation has not been ruled out. At present, the evidence from pseudogenes fits reasonably well into an evolutionary interpretation, for those who choose to make that interpretation. However, there is much about the operation of the genome in general, and pseudogene sequences in particular, that is not well understood. Rapid progress is being made in understanding how the genome operates, and it is reasonable to expect that greater understanding of the meaning of pseudogenes will be forthcoming.*

### INTRODUCTION

Theists and naturalists have long argued over whether nature provides evidence of design. Many theists have claimed that nature is so designed that one can infer the existence of a designer. Some theists have made

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\*updated edition

the stronger claim that nature reveals a designer who is the Creator God revealed in the Bible. Many examples of apparent design have been described, ranging from the non-random properties of the universe to the intricate mechanism of a living cell. To the theist, these features speak clearly of the existence of an intelligent Creator who created with a purpose in mind.

Naturalists have responded with arguments of their own. One argument that is currently popular is the claim that many features in nature are not designed very well. It is affirmed that such poor design indicates either an inferior designer or no designer at all. Several examples of allegedly poor design have been proposed (e.g., Miller 1994). One of the most difficult examples for theists to explain is probably the existence of certain DNA sequences known as pseudogenes. This paper will explore some of the characteristics of pseudogenes and their relationship to the argument for or against design.

### **WHAT ARE PSEUDOGENES?**

Ordinary structural genes are made of DNA sequences that contain coded information for making a particular protein molecule. The information includes a start signal, coding for the sequence of amino acids needed to make up the protein, and a stop signal. Additional signals that regulate the timing of gene activity are found adjacent to the gene, and often also at some distance from it. The amino acid-coding sequence is often broken up into portions known as “exons,” which are separated by spacer sequences known as “introns.” Pseudogenes are DNA sequences that appear similar to functional genes, but contain important defects that appear to make them incapable of producing a functioning protein (Proudfoot 1980). Defects of pseudogenes may include lack of a start codon, presence of extra stop signals, and abnormal or absent flanking regulatory elements. It is thought that mutations in pseudogenes are neutral, and hence free from selection. The first report of a pseudogene was in 1977 (Jacq, Miller & Brownlee 1977). Since that time, a large number of pseudogenes have been described in humans and a wide variety of other species. The supposed defects of pseudogenes have been used as an argument that nature is too poorly designed to attribute its existence to special creation by a supernatural Designer (Miller 1994).

Two types of pseudogenes are known: unprocessed pseudogenes and processed pseudogenes. Processed pseudogenes are found on differ-

ent chromosomes from their functional counterparts. They are called “processed” because they appear to be altered copies of active genes. They lack introns (spacer sequences within a gene) and certain regulatory sequences located in front of the gene, they often terminate in a series of adenines, and are flanked by direct repeats. (“Direct repeats” are associated with movable genetic elements, which may in some cases play a role in inserting a pseudogene into a chromosome.) Processed pseudogenes may be complete copies of the coding sequence, or may be incomplete copies, or may have additional inserted sequences. They seem to be present only in mammals (Vanin 1985). Processed pseudogenes are believed to have arisen in a three step process. The first step is copying of the DNA message into an RNA transcript. The introns are then edited out of this transcript to produce a messenger RNA (mRNA) molecule. Finally, the mRNA is copied back into a chromosome in a process called reverse transcription (see Vanin 1985 for review; see Tchenio et al 1993 for an example). The L1 family of repetitive DNA sequences appears to be the result of this process (Jurka 1989).

Unprocessed pseudogenes are usually found within clusters of similar, functional sequences on the same chromosome (Harris et al. 1984). They typically have “introns” and flanking regulatory sequences resembling a functional gene. As with processed pseudogenes, expression of an unprocessed pseudogene is generally prevented by stop codons. Numerous other differences interpreted as deletions, insertions and point mutations may also be present. A truncated mRNA transcript may or may not be produced. Unprocessed pseudogenes are found in a wide variety of organisms. They are believed to have arisen by gene duplication, which produced an extra copy of the gene. The extra copy, not being needed, could accumulate mutations without harming the organism. Examples of unprocessed pseudogenes are present in the alpha-globin and beta-globin gene families (e.g., see Hardison & Miller 1993 and references therein).

### **THE ARGUMENT FROM SHARED MISTAKES**

When genes for equivalent proteins are compared in different species, they are often found to differ in sequence. In general, the more similar two species are taxonomically the more similar are their DNA sequences, both in general and for specific enzymes. Exceptions do occur, but the overall pattern is easily recognized. Two explanations

have been proposed for the observed pattern of similarities in molecular sequences.

One explanation for sequence similarities is that they are inherited from an evolutionary ancestor. Genes are similar because they are both inherited from a common ancestor. Sequence differences are attributed to accumulation of mutations since the species diverged from their common ancestor. A second, contrasting, explanation is that sequence similarities are due to common design for a similar function. Sequence differences may reflect functional differences, such as might be required for protein function in different metabolic environments, or regulatory function in different genetic backgrounds. It seems unlikely that sequence similarities could be due to chance, but some have been interpreted in this way (e.g., Djian & Green 1992).

Similarities in functional sequences for the same protein in different organisms are to be expected, since they perform similar functions; however, what about similarities in sequences, such as pseudogenes, that seem to have no function? Pseudogenes are commonly thought to be flawed copies of functional genes. It has been argued (Max 1987, Gilbert 1993, Miller 1994) that similar pseudogene sequences shared by two or more species are best explained as the result of common ancestry, assuming that an intelligent designer would not repeatedly make mistakes in creating genes. This can be called the “argument from shared mistakes.”

Comparison of DNA sequences from humans, chimp and other mammals reveals a considerable number of shared pseudogenes that are similar in sequence as well as in positional relationship to other genes. Humans and chimps have many similarities; this is interpreted as indicating a recent common ancestry for humans and chimps (Gilbert 1993). The best known example of a shared pseudogene is the eta globin (psi beta globin) gene, a member of the beta globin gene family.

### **THE BETA GLOBIN FAMILY AND THE (ETA GLOBIN) PSEUDOGENE IN HUMANS**

Human hemoglobin molecules are made of two sets of proteins, produced by the alpha globin genes and the beta globin genes. Both beta globin and alpha globin genes occur in “families” of non-identical copies. The beta globin gene family is located on the short arm of human chromosome 11 (11p15.5), near the gene for insulin (Lalley et al. 1989).

A family of alpha globin genes is also present in mammals, but it is located on a different chromosome (16p13).

The beta globin gene cluster consists of five somewhat similar functional genes and one pseudogene. The five functional genes are arranged on the chromosome in a sequence that corresponds to the sequence of timing of their respective functions during growth and development. The first gene in the series is the “epsilon globin” gene, which helps form hemoglobin molecules early in embryonic development. The second and third genes are called “gamma-G” and “gamma-A.” They help form hemoglobin molecules later during fetal development. The “eta globin” pseudogene is next in sequence, followed by the “delta” globin gene which is produced at a low rate in adults. The last gene in the series is the “beta” globin gene, which produces most of the adult beta globin, and gives the gene family its name. As the adult globin genes become functional, the fetal genes are turned off. The fact that the sequence of the genes on the chromosome matches the sequence of their activity in the developing organism seems unlikely to be the result of chance, and can easily be interpreted as the result of intelligent design.

The eta globin sequence has several characteristics of pseudogenes. It resembles the other members of the beta globin gene family, but is most similar to the gamma-A globin gene. However, it has some important differences. Compared with the gamma-A globin gene, the eta globin pseudogene lacks a start codon (AUG) in the appropriate position. It also has numerous extra stop codons which would be expected to prevent production of any protein. No mRNA transcript or protein product has been identified, and it appears that none is produced. No medical defect is known that is traceable to the loss of this pseudogene. In short, the eta globin sequence is not associated with any known function or defect, and appears to be incapable of producing a useful molecule.

The beta globin gene family is also found in other mammals. Sequences of the human gamma-A globin gene and eta globin pseudogenes from humans and several other species have been compared (Chang & Slightom 1984). The human gamma-A globin gene contains three exons (portions of the DNA that code for amino acids) of 92, 223 and 129 nucleotides, respectively, for a total of 444 nucleotides. The corresponding “exons” of the human eta globin pseudogene differ from the gamma-A globin gene exon sequences in 29, 38 and 43 nucleotide positions, respectively, for an overall difference of 24.8%. The gamma-

A globin gene has two introns, of 122 and 877 bases, respectively. These differ from the “intron” sequences of the eta globin pseudogene by 46-79% and 72-94%, respectively (my figures differ somewhat from those of Goodman et al. 1984, probably due to problems in aligning the sequences). The gamma-A-globin exons and pseudogene “exons” are more similar to each other than expected from random sequences, while the “intronic” sequences are so different that no relationship among them can be inferred.

### **COMPARISONS OF ETA GLOBIN PSEUDOGENES IN HUMANS AND OTHER PRIMATES**

The arrangement of the beta globin gene family in other primates is very similar to that in humans (Harris et al. 1984). Humans, chimpanzees and gorillas have the same number of beta globin genes arranged in the same sequence. In chimpanzees, the beta globin group is on chromosome 9, which is equivalent to human chromosome 11 (Lalley et al. 1989). Baboons have a similar arrangement, but the delta globin gene appears non-functional, and is classified as a pseudogene. The New World owl monkey has only one gamma globin gene, with a possible partial second gene (Meireles et al. 1995), but the arrangement of genes is otherwise the same as in humans. This is true also for the galago (“bush baby”; Hardison & Miller 1993). Among non-primates, the rabbit has only one gamma globin gene, but lacks the eta globin pseudogene, while the delta globin gene appears to be a pseudogene.

The DNA sequences of the eta globin pseudogene exons in humans, chimpanzees and gorillas are similar. The chimpanzee eta globin pseudogene exonic DNA differs from the human eta globin pseudogene at six nucleotide positions and from the corresponding gorilla pseudogene at seven positions. One of these differences The gorilla pseudogene exonic DNA has three differences from humans and seven from chimpanzees. This means that chimpanzee and gorilla eta globin exon sequences are both slightly more similar to the human pseudogene than to each other.

It is clear that the “exon” portions of the eta globin pseudogenes in humans, chimps and gorillas are highly similar. None of their differences involves any of the eight stop codons in the pseudogenes. Several potential initiation codons (AUG) are present, and one of the differences in the chimpanzee produces an additional potential initiation codon in the second exon. However, none of these is sufficient to support protein coding function.

## GENE DUPLICATION HYPOTHESIS

If evolution is to occur, new genes must somehow be produced. The most popular explanation for the evolution of new genes is that they are modified from extra copies of existing genes. This explanation is known as the gene duplication hypothesis (Ohno 1970). According to this hypothesis, functional genes may be duplicated accidentally. The duplicate gene is not needed by the organism. Both copies of the gene may be subject to selection until one of them suffers a disabling mutation, such as a premature stop signal. This disables the gene so it no longer has any function, and is no longer subject to natural selection. It has become a pseudogene, and all subsequent mutations are neutral. Over time, mutations accumulate in the pseudogene. Eventually, according to the theory, random mutations may produce a new gene with a new function (e.g., see Long & Langley 1993).

The gene duplication hypothesis, although widely accepted, is not without some theoretical and empirical difficulties. Assuming the original gene had been optimized by selection, mutations in the coding region of the duplicated gene prior to a disabling mutation would likely result in production of inferior protein molecules. Individuals with one gene that produced inferior protein products would likely be selected against. Spread of a duplicated gene should be difficult under these conditions.

This problem could be reduced if mutations destroyed the function of the extra gene copy early in its history. However, there are only three stop codons, while there are 61 codons for amino acids. One would expect mutations resulting in destruction of function to be much less common than those resulting in production of variant proteins, most of which could be expected to be inferior. Selection may also oppose maintenance of a pseudogene, since it may retain enough activity to disrupt normal cellular activities. Some pseudogenes are suspected to be involved in causing certain diseases (e.g., Wedell & Luthman 1993, Brakenhoff et al. 1994), which should result in negative selection against them. Thus, establishment and maintenance of a pseudogene by gene duplication may require a rather special sequence of events.

Walsh (1995) has calculated the theoretical conditions thought necessary for establishing the presence of a pseudogene in a population, assuming the pseudogene arose randomly by mutation. Establishment requires a high proportion of favorable mutations, a large number of reproducing individuals in the population, and a high selection coefficient.

It seems doubtful that these calculations can explain the frequency of pseudogenes in living species, and some other explanation would be preferred.

Another problem for the gene duplication hypothesis is that the existence of duplicate copies of a gene does not necessarily permit one of the copies to diverge from the others. For example, seven copies of the “Enhancer of split” gene are present in *Drosophila*, but it appears that none of them is free to mutate (Maier et al. 1993). The “duplicated copies” are not extra, but all seem to be required. Many genes occur in multiple copies that remain similar to each other rather than diverging. This has been explained as due to a process known as gene conversion, in which one DNA sequence is “converted” during copying to match another sequence. This may result in maintenance of similarity among several copies of a sequence. The situation in which multiple copies of a sequence maintain close sequence similarity is known as “concerted evolution” (e.g., Moore et al. 1993). Concerted evolution would tend to prevent divergence of duplicated genes, thus presenting a problem for the gene duplication hypothesis. Another problem with the gene duplication hypothesis is that tetraploid species have far fewer pseudogenes than would be expected (Larhammar & Risinger 1994).

Despite some difficulties in attributing evolution of new information from gene duplication, there seems to be evidence that gene duplication does occur. An apparent example of parallel gene duplications in flies has been described (in Menotti et al. 1991).

### **BETA GLOBIN GENES AND THE GENE DUPLICATION HYPOTHESIS**

It is thought that the eta globin pseudogene originated by duplication of a gamma-A globin gene, because of the similarity in their sequences. Both genes are present in all primates studied. Other mammals may have one or the other of the two genes. For example, gamma globin, but not eta globin, genes are present in rabbits; goats have eta globin but not gamma globin genes (Hardison & Miller 1993); the opossum has neither (Goodman et al. 1987).

It would be useful to review the evolutionary explanation for the distribution of eta globin genes in mammals. The proposed explanation is that the common ancestor of marsupials and placental mammals lacked both genes. After the evolutionary divergence of the marsupials, the gamma globin gene formed by duplication of an existing gene in the



beta globin family. Later, but before radiation of the orders of placental mammals, the eta globin gene formed from a duplicated gamma globin gene. This second supposed gene duplication is estimated to have occurred at least 140 million years ago (Harris et al. 1984). Gamma and eta genes must both have been present in ancestral placentals, but presumably gamma was lost by goats and eta was lost by rabbits.

According to this scenario, the eta gene must have been functional at first, because it is functional in goats. It is non-functional in all primates, which is interpreted to mean it was already nonfunctional in the ancestral primates. According to Martin (1993), primates probably originated in the Late Cretaceous, perhaps 70 to 80 million years ago. This interpretation implies that the eta globin pseudogene has been maintained for more than 70 million years without being converted into a useful new gene and without being eliminated. The persistence of a non-functional DNA sequence in an entire lineage for such a supposed long period of time seems remarkable in the context of the gene duplication hypothesis.

The gamma globin gene is believed to have duplicated a second time, producing the A-gamma and G-gamma genes. Humans, apes, Old World monkeys, and some New World monkeys have two functional gamma globin genes. Other mammals, including galagos, tarsiers and rabbits, have only a single gamma globin gene (Hayasaka et al. 1993, Hardison & Miller 1993). To explain this, the gamma globin gene is postulated to have undergone a second duplication after divergence of simians and tarsiers. Current interpretation of the fossil record of primates (Martin 1993) suggests that simians and tarsiers diverged during the Paleocene, perhaps 60 million years ago. It seems remarkable that both copies of a duplicated gene could remain functional for 60 million years if evolution has depended on gene duplication for the source of new genetic information.

### **THEOLOGICAL PRESUPPOSITION IN THE ARGUMENT FROM SHARED MISTAKES**

Several factors need to be considered in interpreting DNA sequence similarities in the eta globin pseudogenes. The argument has been presented that eta globin pseudogene similarities are compelling evidence of shared ancestry. This argument rests almost entirely on two assumptions: that the eta globin pseudogenes have no function; and that God would not create similar non-functioning sequences in separate species. Thus these assumptions must be carefully examined.

The argument that God would not act in a certain way is a theological argument, and can hardly be addressed by science. The validity of such an argument depends on the kind of God being postulated. The kind of God at issue for most of those involved in this discussion is the God who revealed Himself in the Bible. The question then is: What do the scriptures say about whether God would create structures or DNA sequences for which we can find no use in unrelated organisms? This subject is not addressed in the Bible, leaving us without an answer. We can postulate that God would not do such a thing, but this position would not be based on any evidence other than our own presuppositions, however reasonable they seem.

Another theological argument that has been advanced against some proposed actions of God is that God would not deceive us by acting in certain ways. This is equivalent to claiming that our understanding of nature can be trusted to accurately reveal God's activities. This argument is especially dangerous because it places human reason above divine revelation. The scriptures do state clearly that God does not deceive us, but they also make it clear that we are naturally prone to make wrong conclusions. The scriptures reveal the truth about history. When God tells us in scripture that He created in a certain way, we need not be deceived by what we believe to be appearances to the contrary. Our experience should teach us that much.

The argument that we can figure out what God would or would not do has not done well historically. At various times it has been claimed that God would create only perfectly circular orbits for the planets, or that God would create only perfect species that would not need to adapt to changing circumstances, or that God would not permit man to contaminate space. None of these arguments has survived. Claims about God's activities should be based on scripture.

### **SCIENTIFIC PRESUPPOSITION IN THE ARGUMENT FROM SHARED PSEUDOGENES**

A second assumption underlying the argument from shared mistakes is that shared pseudogenes, in this case the shared eta globin pseudogenes, have no function. Has it been demonstrated that these sequences have no function?

It is difficult to completely rule out any possibility of polypeptide production based simply on coding sequence. Examples are known in which the apparent DNA message is altered by RNA editing, reading

frame-shifting or skipping parts of sequences (Benhar & Engelbert-Kulka 1993, Dietz et al. 1993, Gesteland et al. 1992, Landweber & Gilbert 1993). Nevertheless, the available evidence seems to suggest that the eta globin pseudogene does not code for any protein. No RNA transcript or protein product has been identified. Each of the three “exons” contains at least one stop codon in each of the three “reading frames.” (“Reading frames” differ in which nucleotide of each base triplet is used as the starting point.) Seven potential start codons are present, but none of them is in “exon” one. These potential start codons are not sufficient for protein coding function. However, some pseudogenes may produce small amounts of polypeptides in specific tissues (Weinshank et al. 1991, Bristow et al. 1993, Misra-Ress, Cooke & Liebhaber 1994), so it is difficult to rule out the possibility that the eta globin sequence might produce a polypeptide.

DNA strands come in complementary pairs. One might wonder whether the DNA strand complementary to the pseudogene might have some function, but there seems to be no information available regarding this.

The eta globin pseudogene does not appear to function in chromosomal structure. Chromosomes are organized into loops that are attached at their bases to a nuclear material often called the nuclear scaffold. Scaffold associated regions are present within the beta gene cluster, and one of them is located near the eta globin pseudogene (Jarman & Higgs 1989). However, it appears that the scaffold associated region is not within the pseudogene sequence itself, making it unlikely that the pseudogene sequence functions in chromosomal structure.

The observation that the eta globin pseudogene is not associated with any known genetic defect is offered as further argument for its lack of function. Several hemoglobin beta globin abnormalities are known, but none of them is associated specifically with the eta globin pseudogene (Stamatoyannopoulos & Nienhuis 1994). This is interpreted as supporting the assertion that the pseudogene has no function. However, this argument is quite weak. The same result could occur for lethal mutations. No defective individuals would be observed because they do not survive long enough to be observed. Individuals with defective pseudogene sequences have been reported, but their abnormal hemoglobins were attributed to deleted portions outside the pseudogene sequence. It would be helpful to know whether normal individuals exist without the pseudogene sequence. Unless more information is available, the argument that

the eta globin pseudogene has no effect on health cannot be said to have been demonstrated.

The possibility that pseudogenes may have some function is worth exploring further. Some pseudogenes are believed to function as sources of information for producing genetic diversity (Fotaki & Iatrou 1993, Wedell & Luthman 1993), possibly involving a process similar to gene conversion. It is thought that partial pseudogene sequences are copied into functional genes, producing variants of the functional sequence. This phenomenon has been reported many times. Some examples include the immunoglobulins of mice (Selsing et al. 1982) and birds (Reynaud et al. 1989), mouse histone genes (Liu et al. 1987), and in horse globin genes (Flint et al. 1988) and human beta globin genes (Fullerton et al. 1994). The possible role of the eta globin pseudogene in gene conversion is unknown.

Regulation of globin genes is not fully understood, but several regulatory sites and protein factors have been identified (Stamatoyannopoulos & Nienhuis 1994). Each of the five functional beta globin genes has its own promoter region that participates in gene regulation. In addition, a locus control region (LCR) is found in a region several thousand bases upstream from the gene for epsilon globin, which is the first to be expressed.

There is no evidence that the eta globin pseudogene functions in gene regulation of the beta globin gene family (Engel 1993). However, that possibility has been suggested (Goodman et al. 1984, see also Vanin et al. 1980). The chromosomal arrangement of beta globin genes in a sequence corresponding to the timing of their activity is striking. It appears that chromosomal location plays an important role in beta globin gene regulation (Dillon et al. 1991).

The fact that the eta globin pseudogene is located between the fetal and adult genes suggests that it could play a role in gene switching—turning off the fetal gamma genes and turning on the adult beta gene. There is evidence that gene switching in human beta globin genes depends in some way on the sequence lying between the fetal and adult genes (Townes et al. 1991), although it is not known whether the eta globin sequence itself is involved. Some pseudogenes have been implicated in gene regulation (Singh & Brown 1991, Assinder et al. 1993, Koonin, Bork & Sander 1994). Such a role could involve competition for regulatory proteins, production of signal RNA molecules, or perhaps some other mechanism (e.g., see Enver et al. 1991).

Further suggestion of possible functionality of the eta globin pseudogene comes from a comparison of the “non-functional” sequences in humans and chimps. Non-functional sequences in this case include the A-gamma gene introns and the entire eta globin pseudogene. One would expect a similar rate of mutation in all non-functional sequences. We can test this by comparing the extent of difference between various regions of the non-functional sequences. Human and chimp A-gamma introns differ by 23 of 999 positions (2.3%). The respective eta globin “introns” differ by 16 of 999 positions (1.6%). The “exons” in the eta globin pseudogene differ by only 6 of 444 positions (1.35%). The figures for A-globin introns and eta globin exons differ by more than one-third. This could be explained as due to variations in the mutation rate, but this would tend to undermine the argument that differences in non-functional sequences are a function of time (the molecular clock hypothesis). It seems reasonable to suspect that mutations in the eta globin pseudogene “exons” are constrained, perhaps because it has some function that has yet to be discovered (cf discussion of *Drosophila* Adh locus in Sullivan et al. 1994).

Another presupposition of the argument from shared mistakes is that they could not have arisen independently, but must have been inherited from a common ancestor. Although convergence and parallelism are common problems in morphological studies (e.g., Carroll & Currie 1991), it seems improbable that identical nucleotide changes would occur independently. However, there is some evidence that nucleotide changes may not be random. Mutational “hotspots” (e.g., Hardison et al. 1991) have been identified, and independent gene duplication events have been inferred (Menotti, Starmer & Sullivan 1991).

### **ARE PSEUDOGENES “JUNK DNA”?**

It has been thought that only a small proportion of DNA codes for proteins. Typical estimates have been that perhaps 3% of the genome is involved. Recent discoveries (Wilson et al. 1994) indicate a figure closer to 30%. What is the function of the remaining portion? A large amount of DNA would be required for gene regulation, but this still leaves a significant part of the DNA with unknown function. That DNA fraction with no apparent function has been called “junk DNA.” Junk DNA has been thought to include intervening sequences (introns), satellite DNA (a highly repetitive DNA fraction), repetitive sequences, and pseudogenes.

As knowledge of the genome has increased, functions have been discovered for some of the sequences thought to be “junk” (Nowak 1994). For example, introns function in splicing together transcripts of exons. This constrains the kinds of changes that intronic sequences can tolerate. Some introns contain coding sequences which produce functional gene products (see Doolittle 1993 for review). Satellite DNA appears to be involved in chromosomal structure, especially at the ends (telomeres) and attachment points (centromeres) of the chromosomes. Repetitive DNA seems to have effects that are not well understood. Some diseases seem to be related to repetitive sequences (see Maddox 1994). It was recently noted that repetitive sequences seem to have a genomic arrangement characteristic of some kind of information code (Flam 1994), although the test used for this is apparently a weak test. Some supposed pseudogenes have been shown to be lowly or selectively transcribed (e.g., Yaswen et al. 1992, Imai et al. 1993, Vazeux, le Scanf & Fandeur 1993), which might suggest some function. The list of DNA sequences that have no effect on the organism has steadily decreased as knowledge of the operation of the genome has increased. This is reminiscent of the history of vestigial organs, in which apparent lack of function was actually lack of knowledge of what the function was. There is still much about pseudogenes that is not understood (Sullivan et al. 1994).

In retrospect, it seems perfectly reasonable to expect most DNA sequences, as well as organs, to have some function. One of the rules of nature seems to be that structures that are not useful tend to become lost. This is not to say that all DNA sequences must have a function. Copying errors, unequal crossing over and disruptive transposition all may contribute to the accumulation of useless DNA sequences. Many pseudogenes may indeed be junk DNA. However, the argument that particular DNA sequences must not have a function because we haven't discovered any function for them is an argument from silence. To conclude that pseudogenes are junk DNA seems premature.

### **SUMMARY AND CONCLUSION**

Pseudogenes are DNA sequences that resemble functional genes but seem to have no purpose. The presence of similar eta globin pseudogenes in humans and chimps has been used as an argument for common ancestry of the two species. The argument has two parts: that the pseudogene sequences actually have no function, and that God would not create

similar non-functional sequences in humans and chimps. The latter argument is theological, and is similar to many other theological arguments that have been proposed and later abandoned. Theological arguments should not be relied on unless well supported by scripture.

The argument that the eta globin pseudogene has no function is consistent with most of the data, although lack of function has not been demonstrated. Possible function is suggested by the location of the pseudogene and differences in the extent of divergence of “intronic” and “exonic” sequences. The possibility that the eta globin pseudogene provides a binding site for a molecule involved in gene regulation has not been ruled out. At present, the evidence from pseudogenes fits reasonably well into an evolutionary interpretation, for those who choose to make that interpretation. However, there is much about the operation of the genome in general, and pseudogene sequences in particular, that is not well understood. Rapid progress is being made in understanding how the genome operates, and it is reasonable to expect that greater understanding of the meaning of pseudogenes will be forthcoming.

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