EDITORIAL

"RETRO-PROGRESSING"

As one browses through the history section of a library, one of the volumes that is likely to catch one's attention is The Discoverers *by Daniel Boorstin.*[1] *It is an impressive, 700-page volume. Published in 1983, it chronicles in a semi-popular style selected aspects of man's discoveries. Two chapters entitled "The Prison of Christian Dogma" and "A Flat Earth Returns" deal with the outlandish concept of an earth that is flat instead of spherical.*

Boorstin has impressive academic credentials from Harvard and Yale, and has held prestigious positions such as the Librarian of Congress, Director of the National Museum of History and Technology, and Senior Historian of the Smithsonian Institution. In The Discoverers *he reflects the popular view that the ancient Greeks, including Aristotle and Plato, believed Earth to be a sphere; however, after the rise of Christianity a period of "scholarly amnesia" set in which lasted from around 300 to 1300 A.D. During this time, according to Boorstin, "Christian faith and dogma replaced the useful [spherical] image of the world that had been so slowly, so painfully, and so scrupulously drawn by ancient geographers." The "spherical" view was replaced by the concept of a flat earth, which Boorstin characterizes as "pious caricatures."*[2] *Boorstin bolsters his case by mentioning a couple of minor writers — Lactantius and Cosmas — who believed in a flat earth and lived during this "dark age." He also implicates the powerful authority of St. Augustine of Hippo (354-430), who "heartily agreed" that antipodes "could not exist."*[3] *Antipodes represented lands on the opposite side of a spherical earth where trees and men, if present, would be upside down, with their feet above their heads; hence, the "antipodes" (opposite-feet) designation.*

The picture given by Boorstin represents conventional wisdom for the past century and is found in many texts and encyclopedias.[4] *It has been especially popularized in the context of the story of Christopher Columbus, who is depicted as the hero who dared to defy Church dogma about a flat earth. This courageous adventurer went on to discover America, and he accomplished this feat without even falling off the edge of the flat earth. Many students in the*

United States and other countries have been taught this version, which serves as an example of how empirical investigations have triumphed over arbitrary Church dogma.

The idea of the Christian Church's belief in a flat earth during medieval times has turned out to be flatly fallacious. Jeffrey Burton Russell, professor of history at the University of California at Santa Barbara, has recently published a book entitled: Inventing the Flat Earth: Columbus and Modern Historians.[5] *This thoroughly documented study indicates that the supposed link between the early Christian Church and the flat-earth concept is a recent historical invention. The early Greek perception of a spherical earth, somewhat similar to the sun and moon, was never lost. Virtually all the leading medieval scholars believed in a spherical earth. These included well-known writers and Church authorities such as the Venerable Bede (673-735); John Scottus Eriugena, the leading philosopher of the 9th century; Roger Bacon (c. 1220-1292); St. Thomas Aquinas (1225-1274), and Dante Alighieri (1265-1321).*

Furthermore, the rotation of the earthly sphere was discussed by Jean Buridan and Nicole Oresme, the leading 12th century scientists. Russell points out that even St Augustine, who is cited by Boorstin as a supporter of the flat-earth idea, seems to have believed in a spherical earth. In his cautious style Augustine suggests that even if there is land on the opposite side of the earth, it is not inhabited.

Furthermore, the sphericity of the earth was not a problem for Columbus as he sought sponsorship from Ferdinand and Isabella of Spain for his daring voyage which landed him in the New World in 1492. Although there were serious questions about the distances he would be traveling, all of the different estimates were based on the assumption of a spherical world. It is probable that some at that time believed in a flat earth — as is the case for some individuals today —, but this was not at all the prevailing concept. According to Russell, during the first fifteen centuries of the Christian era, only five writers disavowed the sphericity of the earth, while a "nearly unanimous scholarly opinion pronounced the earth spherical."[6] There was no heretical "dark age" of theological opinion about a flat earth which Columbus had to oppose.

How and why did this modern-day heresy about medieval times develop? There are some suggestions. In 1828, the popular essayist/

novelist Washington Irving published a dramatic account of a confrontation between Church dignitaries and Columbus about the sphericity of the earth. Irving seemingly allowed his imagination to have free reign. His account, which is now considered a fabrication, had some influence on accounts chronicled later in the 19th century. Within the academic community, a more important influence was that of the Vice-Chancellor of Cambridge University, William Whewell, who in 1837 published his History of the Inductive Sciences. *Here he refers to the flat-earth views of Lactantius and Cosmas as representing the medieval perspective. Subsequently, without rechecking the facts, other scholars have repeated his thesis.*

The 19th century was a time of great intellectual unrest. The Enlightenment movement of the 18th century had laid the foundation for the institutionalization of science, and there was great ferment about the authority of science and that of the religious establishments. This was a prime opportunity to suggest how wrong the Church had been in defending the flat-earth concept. In the latter part of the century, two very widely distributed books succeeded in doing this. The books were: History of the Conflict Between Religion and Science *by John William Draper (1811-1882),*[7] *and* A History of the Warfare of Science with Theology in Christendom *by Andrew Dickson White (1832-1918).*[8] *At that same time the ongoing controversy over evolution and the poignant question of the origin of man did much to enhance interest in these books.*

Draper, who abandoned the religious faith of his family, stressed how the Church — especially the Roman Catholic Church — was the enemy of science. He emphasized the antagonism between religion and science, considering it to be "the most important of all living issues."[9] *He depicted theologians rejecting the idea of a spherical earth and attacking Columbus as he attempted to gain support for his famous voyage. White also rebelled against his religious upbringing. As the first president of Cornell University, the first explicitly secular university in the United States, he faced strong religious opposition. White reinforced Draper's thesis that religion, and especially theology, smothered truth. White, apparently being aware that many Church authorities believed that the earth was a sphere, was slightly more moderate in his comments, but supported the imaginary conflict by claiming that those authorities*

who believed in a spherical earth were not accepted by the majority. Draper and White were promoting the superiority of science, and in doing this they created "a body of false knowledge by consulting one another instead of the evidence."[10] Curiously, both writers were accusing the Church of propagating error while they were indulging in the same practice to make their point. Fortunately, in the past few years, several textbooks and other references have corrected the myths about Christopher Columbus and the purported medieval Christian belief in a flat earth.

It is disappointing to see that an imagined flat-earth story can define "truth " in such a strong way. Such falsehoods cause us to "retro-progress." This is especially disappointing when done under the specific claim that we are progressing forward. When our intellectual pursuits create prejudicial falsehoods, it is time for careful reevaluation. The "flat-earth" concept has become a cliche for depicting the ignorance of the past, when actually the use of this cliche underlines our own ignorance about the past! We all make mistakes — many of them honest mistakes — and we should be tolerant while helping each other in the correcting process. However, when something as deprecating and prejudicial as the flat-earth fallacy becomes so widely accepted, it warns us about how delusional our so-called "scholarly" pursuits can be. How many undetected erroneous concepts are lurking around in our textbooks and on the shelves of our libraries — to say nothing about the World Wide Web?!

Be vigilant.

Ariel A. Roth

ENDNOTES

1. Boorstin DJ. 1983. The discoverers. NY: Random House.
2. Ibid., p 100.
3. Ibid., p 107.
4. For further discussion of these interesting developments see: Gould SJ. 1994. The persistently flat Earth. Natural History 103(3):12,14-19.
5. Russell JB. 1991. Inventing the flat Earth: Columbus and modern historians. NY: Praeger Publishers.
6. Ibid., p 26.

7. Draper JW. 1875. History of the conflict between religion and science. 5th ed. NY: D. Appleton & Co.
8. White AD. 1896, 1960. A history of the warfare of science with theology in Christendom. 2 vols. NY: Dover Publications.
9. Draper, p vii.
10. Russell, p 44.

ARTICLES

PARADIGM AND FALSIFICATION: TOOLS IN A SEARCH FOR TRUTH

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WHAT THIS ARTICLE IS ABOUT

In the 1960s Thomas Kuhn and Karl Popper became two of the best-known philosophers of science. Kuhn stressed "paradigm" and Popper "falsification" as important principles that influence the practice of science. The purpose here is not to analyze whether they are correct, but rather to see how we might best profit from these two principles.

The idea of paradigm is that a group of people are united in subscribing strongly (often without realizing it) to a certain set of understandings of some area of science. Accordingly, they can progress further in research without having to start all over making the basic discoveries.

The idea of falsification is that one should not accept a new finding uncritically, but should do one's best to devise experiments to discredit (falsify) it; that which survives the hardest tests is taken as the closest to truth.

Three conclusions are drawn here:

a. *The paradigm concept is useful in assuring efficiency of research — the framework is already built. But there should also be heavy emphasis on an alternative-hypothesis approach, in the hope that it might foster some openness even to an alternative-paradigm approach.*
b. *The falsification concept is useful in assuring rigor in research — an attempt to falsify a conclusion is a real test of it. It can increase the quality of evidence.*
c. *Sufficient higher-quality evidences could help choose between whole paradigms — a most difficult but important task.*

Finally, applications to religion are proposed (Appendices).

INTRODUCTION

In the 1950s while a graduate student at Stanford University, I was impressed by some guest lectures by William Pollard. He was both a practicing physicist (research and teaching) and a practicing Christian clergyman. His thesis was that to be a true physicist, one had to "enter the community" of physicists. Sometimes he would receive crank letters (for example, proposing a new perpetual motion machine) from people who obviously had not entered the community. Most of his students did not enter either, but occasionally one would catch the light and start going all out for physics (not grades).

Likewise Pollard said that to truly evaluate Christianity, a person would have to enter the community of Christians; short of this, even one claiming Christianity would grossly misrepresent it both personally and to others. I did not know it then, but came later to realize that these lectures had effectively introduced me to the concept of "paradigm," the first of the two main topics of this essay.

In 1965 a classic paper (Chamberlin 1890) on multiple hypotheses was republished. It showed the enormous value (though involving *hard* work) of setting up alternative explanations. Again, only later did I realize that this prepared me to appreciate "falsification," the other main topic here.

Two of the most influential philosophers of science in recent years have been Thomas Kuhn and Karl Popper, as reflected in Kuhn's *The Structure of Scientific Revolutions* (1962), and Popper's *The Logic of Scientific Discovery* (1959 English translation). This is not to say that they have been universally accepted (cf. Hacking 1983, Lipton 1993); but rather that the contributions are important enough that one should be acquainted with them.

My purpose here is to outline these contributions as stated in the classic books cited above, then to consider how they might best promote understanding and advancement in science, and in religion as well. (As a specific example of the latter, the Bible will be referenced in a series of notes keyed to the text [Appendix I].)

Each subtopic under **KUHN AND PARADIGM** below starts with an abstract (on green background) of Kuhn's position, keyed to page references in his book; this is usually followed by possible implications as I see them for the study of science and/or religion. Then the same is done under **POPPER AND FALSIFICATION**.

KUHN AND PARADIGM

Definition

> According to Kuhn, "normal science" means research firmly based on past achievement which, for some particular scientific community, supplies the foundation for its further practice. The closely related term "paradigm" is used for achievement both (a) unprecedented enough to attract an enduring group of adherents away from competing modes of scientific activity; and (b) open-ended enough to leave all sorts of problems for the redefined group of practitioners to resolve.
>
> In other words, a paradigm represents a particular, coherent tradition of scientific research. People with research based on a shared paradigm are committed to the same rules and standards for scientific practice. (p 10-11)

Advantages

> Therefore a paradigm approach makes for great efficiency. It ends having to constantly reiterate the fundamentals. Instead, one can begin where the textbook leaves off.
>
> It inspires a confidence that this is the way to go, encouraging more precise, knowledgeable, or consuming work.
>
> Its high focus compels investigation of some part of nature in a detail or depth otherwise unimaginable. Problems are solved that would scarcely be imagined possible — that would not even have been undertaken without commitment to the paradigm. (p 18,20,24,25)

Because working within a paradigm provides such a stable base, one can study interrelations within the field better, and there can be greater harmony among workers in different subfields. It is easier to recognize where there is need for more study or better understanding.

In sum, there is greater progress not only because of the intense focus provided, but also because of the basic consensus within the committed group.

If the paradigm concept plays such a role in the advancement of science, it should be more often recognized for what it is. One possible example, where there is now real polarization, relates to the abrupt vs gradual origin of the major diversity in living things (and of astronomical entities). To even properly evaluate the less popular abrupt-origin paradigm would require a much more intense, long-term effort than is usually given — a commitment that might get a person, in a sense, "inside" the paradigm. But that is more demanding (or distracting) than many people would want to consider.

Disadvantages

A paradigm could be seen as an attempt to force nature into a relatively inflexible box, blinding one to other possibilities. It becomes the very criterion for identification of problems assumed to have solutions. Other problems are rejected, for example, as metaphysical *["metaphysics" is that which is untestable, or at least has not been tested — see FALSIFICATION section below]*. In fact, it may be difficult even to invent certain concepts that another paradigm would suggest.

Because discovery involves fact plus assimilation to theory, it is a process and takes time. Therefore one should expect acceptance of a new paradigm to take a great amount of time and effort. (p 7,24, 37,55,142-143)

One of the great advantages of a paradigm approach, the extremely intense focus involved, *could* also be a disadvantage:

1. It might delay consideration of a valuable new paradigm.
2. It could discourage use of another paradigm as a valuable source of ideas.
3. Finally, a possible cost of research that follows a paradigm pattern is being less prepared for the *really* innovative.

Relation Between Paradigm and Textbook

By intent, by the very definition of paradigm, science textbooks (and popularizations and philosophical works modeled on them) are severely circumscribed. Further, they not only ignore anomalies or other paradigms, but truncate or distort history, and hence are deceptive. Even scientists looking back at their own research tend to make it look linear or cumulative toward what they finally realized was the answer. And graduate programs often emphasize textbooks to the neglect of original literature.

Such circumscription is good insofar as it facilitates the advantages of a paradigm approach, such as the utmost efficiency in preparing for a highly focused, unified life of research. But such training is not well designed to produce people likely to discover such a fresh approach as that involved in a new paradigm. (p 136-141,165-166)

It is important to recognize how circumscribed, and in fact deceptive, textbooks (and derived popularizations and philosophical works) can be. Authors themselves may unwittingly fail to understand how paradigm-bound they are.

A more healthy perspective for present-day science would come from a better analysis of history, of which Kuhn gives many examples. He

outlines the tortuous pathway by which many major "discoveries" were actually made. Such analysis improves preparation for being truly scientific.

This is not to say that textbooks should not be written within a particular paradigm. But it does call for choosing or developing textbooks (and syllabi) that at least include alternative hypotheses, are less dogmatic, and are open to more than one world view. Further, more assignments and recitations should be from the original literature.

Our own study or research should incorporate an alternative-hypothesis approach — and even an alternative-*paradigm* approach — more often. And we might more judiciously choose books for student (and faculty) reading lists.

The next section asks explicitly just how changes from one paradigm to another occur.

How Do Revolutions Come About?

> Scientists living in different worlds (that is, paradigms) may have different perceptions from a set of observations; so "before they can hope to communicate fully, one group or the other must experience the conversion that we have been calling a paradigm shift." In fact, "to desert the paradigm is to cease practicing the science it defines."
>
> There is such **heavy** constraint even on what one sees, that it is most difficult to change paradigms. Change requires both intense concentration on crisis-provoking problems, and people so young or new to the field that they are less committed to the rules of the prevailing paradigm.
>
> Competition between segments of the science community is the only historical process that results in the rejection of one accepted theory or the adoption of another.
>
> It is most important that there be a legitimate claim that the new paradigm solves critical problems of the old, as well as a demonstration of crucial experiments that sharply discriminate the new from the old. To embrace the new at an early stage requires a faith that it will succeed with the many large problems confronted, in defiance of the problem-solving ability of the old. (p 8,34,62-64,144,150,153,158)

Such use of discriminating experiments suggests at least a limited "weight-of-evidence" basis for commitment* to the new paradigm. This freedom in turn inspires yet further investigation, and a consequent increase or decrease in weight of evidence.

We should expect another paradigm to seem peculiar. If some openness to a new one is important for fundamental progress, there should be

deliberate training for it: stress a multiple-hypothesis approach even in current study or research; concentrate on crisis-provoking problems of the prevailing paradigm and how the new one might solve them; include experiments that clearly discriminate the two.

Ideally there should also be a real "live-in" trial of another paradigm — "entering the community of believers," as Pollard once said (see Introduction). If this seems impossible, at least live with persons who *are* fully within it; that is, spend much time in close acquaintance with them and their work. Favorably consider their arguments, giving as coherent a picture of phenomena as possible through their eyes. This would at least contribute information toward a sound decision.

More evidence should be obtained by thoroughly interviewing those who had lived (grown up?) as genuine supporters of one paradigm, but had decisively changed to another. Their unusual experience would provide a retrospective "live-in" test, with the number of replicates being the number of such people found.

Of final importance is a *weight-of-evidence* decision (as opposed to expecting final "*proof*").

POPPER AND FALSIFICATION

We have seen the value of Kuhn's paradigm concept, emphasizing focus on one belief in common in order to make the most progress. Popper emphasizes another aspect, a scientific method that tests with enough rigor to avoid undue bias; thus it may safely test many alternative ideas, even those metaphysical in origin.

Problem of Knowing

Uninterpreted sense experiences are not in themselves science. A common practice of science (called ***"inductive"*** inference) is to pass from particular statements, such as accounts of observations or experiments, to universal statements, such as hypotheses or theories. But suppose an exception turns up in such a "universal" statement. This is the problem of knowing something "by experience" (see next paragraph). So Popper recommends a directly opposite method, ***"deductive"*** testing — a hypothesis can only be empirically (i. e.,

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* "Faith is often used for belief *not* based on evidence. But why not also for belief that *is* based on evidence, as just illustrated in Kuhn? Thus faith could relate vertically to evidence, building with or on it, rather than standing alongside (as if evidence were "for science" but faith "for religion").

experimentally) *tested* (vs proved), and only *after* it has been advanced. (p 27,28,30,39,280)

"Falsification" Method

A deduction is drawn from the new hypothesis or theory, then tested: if the deduction is *falsified*, the new theory is also falsified; if *verified*, the theory has for the time being passed the test. (So long as it withstands detailed, severe tests, it is said to be corroborated by past experience.) The falsification method thus singles out a scientific system in the negative sense — to be valid it must be open to *refutation* by experience. (p 32-33,41)

Advantages

The method is a means of selecting the very best of hypotheses or theories by exposing them all to the fiercest struggle for survival.

The results provide evidence — an *objective* experience — on which we can decide; rather than just a private *subjective* experience or conviction, which is not open to someone else. There is then a basis for coming to an agreement among ourselves about what is the closest to truth.

The greater the amount of information a universal statement conveys, the more likely it will clash with possible particular statements. That is, the statement is testable more explicitly or in more ways, and hence has survived more tests. To put it another way, the more a law of nature prohibits, the more it says. (p 41,42,44)

The falsification approach should especially appeal to all who are the most interested in truth.

- It provides a methodology for arriving at the best possible understanding, and thus progressing toward ultimate truth.
- It encourages focusing on evidence, for example, via use of multiple hypotheses.
- It facilitates mutual sharing of evidence or experience.
- It discourages hanging on to a conclusion or interpretation because of personal bias. In other words, it forces a rigorous look at traditional or pet interpretations.
- In sum, it provides an ever more solid basis for conviction or action.

Disadvantages

There are no ultimate statements. That is, testability always implies that, from statements which survive testing, further testable state-

ments can be deduced. But if basic statements themselves, in turn, are to be testable, there can be no statements of final truth in science (whereas *inductive* logic says all statements of empirical *[experimental/observational]* science can be either verified or falsified). However, this does not demand that every scientific statement be tested before acceptance; only that it be *capable* of being tested. (p 40,47,48)

The fact that there are no ultimate statements with this method (contrary to the thought of inductive science) might seem a disadvantage. But in a way, it could really be an *advantage*: it points out the importance of going beyond falsification testing. That is, if there are enough items in a system or paradigm that can be tested via falsification, the results could encourage or discourage accepting the whole system via confidence based on the *weight* of evidence (see Table 1). This more secure basis for early decision should apply even to systems of metaphysical origin, *provided, of course, that the above conditions could be met.*

Empiricism vs Metaphysics

Empirical science is that which has stood up to testing; metaphysics is that which has not been tested, or even is in principle unrepeatable. Our business is not to overthrow metaphysics; but rather, to distinguish between it and science. Empirical science must represent the

TABLE 1. Possible relationship between falsification and weight-of-evidence testing; and between metaphysics and science ideas (or whole paradigms) with respect to testing.

SOURCE	TESTABLE VIA FALSIFICATION?	RESULT	TESTABLE VIA WEIGHT OF EVIDENCE?	RESULT
Metaphysics idea	Yes No	Science Metaphysics		
Science idea	Yes No	Science Metaphysics		
Metaphysics paradigm			*If* enough falsifiable components	Basis for decision
Science paradigm			*If* enough falsifiable components	Basis for decision

world of possible *experience* — it has stood up to tests by the deductive (falsification) method The *source* of a new idea or theory is irrelevant to the logic of scientific knowledge; so we distinguish sharply between the process of conceiving a new idea, and the method or results of examining it logically.

Only in subjective experiences of conviction or faith can we be "absolutely certain." Science cannot decide a controversy concerning unrepeatable events: this would be a metaphysical controversy. We may be utterly convinced of truth, certain of the evidence of our perceptions, overwhelmed by the intensity of our experience, with every doubt seeming absurd — but none of this is reason for *science* to accept.

We have a metaphysical faith in the existence of regularities in our world (though we do not argue for or against such metaphysical questions), without which practical action is hardly conceivable. Our guesses are guided by an unscientific, metaphysical (though biologically explicable) faith in laws or regularities we can uncover. Bold ideas, unjustified anticipations, speculative thought — these are our only means for interpreting nature; but if we are unwilling to expose our ideas to refutation, we do not take part in science. (p 30,31,37, 46,252-3,278,280)

To carefully distinguish between empiricism and metaphysics, then, could lead to greater clarity in science, and in religion as well. Further, giving metaphysics proper place might enlarge the source of ideas and alternative hypotheses, thus advancing science.

Danger of Explaining Away Falsification

In a time of crisis, new experiments which we interpret as falsifications are often explained away by questioning adequate mastery of the system, or the reliability or objectivity of the scientist; or by ad hoc auxiliary hypotheses. But that makes it impossible to divide theories on whether they are falsifiable or not. *We* hope to be helped by a new understanding, and are much interested in the falsifying experiment. So be cautious about such explaining away to save a system if it is threatened. If we find such a "rescued" system, it should be tested afresh. (p 80-81,82)

If apparent falsifications are explained away too fast, we may lose the very advantages of this approach (see "**Advantages**" above). (It might be like the saying, "My father's church was good enough for him; it is good enough for me.") Recognize anomalies, and if serious enough, be willing to change theory. It is here that weight of evidence is so important.

Real Quest for Truth

> It is not the *possession* of knowledge, of irrefutable truth, that makes a scientist; rather, it is the persistent, critical quest for truth. This search is carefully controlled by tests — not to defend, or prove right, but to try to overthrow. Thus it is a process of ever discovering new, deeper, and more general problems, of subjecting ever tentative answers to ever renewed and more rigorous tests. (p 279,281)

That, in turn, encourages conviction or action. The more something is defined by what can be rigorously tested, the more dependable the evidence; and it is the *weight of evidence* that enables us to decide or act (as contrasted with absolute certainty of final truth).

SUMMARY OF IMPLICATIONS FOR UNDERSTANDING OR APPLICATION

The falsification philosophy of science draws deductions from a hypothesis, theory, or world view (paradigm) and deliberately tries to falsify them. In fact, if an idea is not capable of being falsified, it is not considered as a part of science. This is rigorous testing, and those ideas or deductions that survive are more dependable than others.

This should make it important for advancement in especially controversial fields of science (or religion). Then one could utilize the weight of evidence from falsification testing, as a basis for firm conclusions about a paradigm, or how to live.

COULD PARADIGM AND FALSIFICATION CONCEPTS COMPLEMENT EACH OTHER?

Could these two concepts be put together? We have seen how useful a paradigm can be toward the intense focus necessary for real advances. In fact, failure to enter a paradigm could mean a great loss.

On the other hand, complete immersion in a paradigm could blind one to the virtues of totally different approaches, or to possible metaphysical truth. Here, falsification testing can be especially useful, because it helps protect against undue bias: what tests something better than deliberately arguing against it?

Further, ideas from both metaphysics and science sources can be tested, since testability of an idea is more important than its source (Table 1). With the high quality of evidence this provides, the weight of evidence becomes more plausible as a basis for decision for (or against) a whole paradigm.

CONCLUSION ON THE USE OF FALSIFICATION IN PARADIGM RESEARCH

A metaphysical idea is one which is either untested or untestable. Whether ideas are disciplined or wild or metaphysical, if they survive falsification testing they provide evidence. Weight-of-evidence testing asks if the crucial falsification experiments, taken as a whole, heavily support one theory or paradigm over another; the outcome could provide confidence for acceptance (or denial) — in other words, a sufficiently secure understanding of nature for real-life usefulness.

Thus things can be checked more rigorously, as a basis for pleasure or practical application. Further, while much of nature (for example, mind or beauty or free will) is hardly subject to a falsification approach, and hence by definition is metaphysical, the untestable part *could* nevertheless be accepted (or rejected) on the basis of the weight of evidence for a whole paradigm.

The merit of this is that even though some body of belief (internally coherent world view or paradigm) is seemingly beyond test, that is not necessarily so. The weight-of-evidence method could reduce the tendency to reject a whole paradigm just because not everything can be tested *directly*.

This method could open up a larger realm of nature or religion, or illuminate it in a new way — both as source of ideas to test, and source of a whole body of belief to test. It could facilitate intelligent (vs blind) choice of a belief system that would bring ultimate meaning to life. This might be of special help (1) to those who treasure an *evidence* (vs simply a "deep-down-in-my-heart-feeling") approach to important things; or (2) to those who might see only a skeptical or cynical way out.

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LITERATURE CITED

Chamberlin T. 1890. The method of multiple working hypotheses. Science (OS) 15:92; reprint 1965, Science 148:754-59.

Hacking I. 1983. Representing and intervening: introductory topics in the philosophy of natural science. Cambridge: Cambridge University Press.

Kuhn TS. 1962. The structure of scientific revolutions. The paperback, popularly available, to which page references are keyed above was published by the University of Chicago in 1970.

Lipton P. 1993. Coordinating science [review of two 1993 books on Kuhn's philosophy]. Nature 364:770.

Popper K. 1959 (English; original German 1934). The logic of scientific discovery. The paperback, popularly available, to which page references are keyed above was published by Harper Torchbooks in 1968.

APPENDICES: POSSIBLE APPLICATION TO RELIGION RESEARCH

APPENDIX I. NOTES ILLUSTRATING SPECIAL TRIAL

Notes 1-6 below could be thought of as "footnotes" from the main text of the paper, as one trial of its concepts in a *non-science* area — specifically Bible research or belief. A (modified) *Text* paragraph is given first, followed by the *Note* springing from it.

#1

Text (p 13): The way Kuhn suggests the value of discriminating experiments in moving from one paradigm to another suggests at least a limited "weight-of-evidence" basis for commitment to the new. This in turn inspires yet further investigation, and hence increase or decrease in the weight of evidence.

Note: By analogy, the same approach could be valid for religion, which should be brought to such a test — including religion "experiments." *Personal* religious living experiments test for oneself, but not for another (except as one replicate). Fortunately there are enough Bible experiences to serve as replicates for use in the more general test suggested here (Appendix III).

#2

Text (p 15): If there are enough items in a system or paradigm that can be tested via falsification, the results could encourage or discourage accepting the whole system via confidence based on the *weight* of evidence (see Table 1). This more secure basis for an early decision should apply even to metaphysical systems, *provided*, of course, that the same conditions could be met.

Note: That in turn might open up the whole area of revelation in such a system. For example, the Bible could become not only a metaphysical source of hypotheses to be tested [via falsification approach]; but also another testable source of a body of truth.

#3

Text (p 16): To carefully distinguish between empiricism and metaphysics could lead to greater clarity in science, and in religion as well. Further, giving metaphysics a place (that is, exposing some of its ideas to falsification testing)

might enlarge the source of ideas and alternative hypotheses, thus advancing science.

Note: Could it provide for inclusion of some hypotheses suggested in the Bible, which might on testing turn out to be valid additions to science itself?. With respect to religion, the careful distinction between metaphysics and empiricism allows two major premises: the Bible as a source of *revelation*, but also as a source of *evidence*. This distinction would invite weight-of-evidence study with a falsification approach; *if* this yields a high *positive* weight, one could then appreciate the Bible in a new way.

#4

Text (p 17): The process of subjecting ever-tentative answers to renewed and more rigorous tests encourages conviction or action. The more something is defined by what can be rigorously tested, the more dependable the evidence; and it is the *weight of evidence* that enables us to decide or act (as contrasted with absolute certainty of final truth).

Note: Such dependable evidence is a superior basis for evaluating the claim that God's revelation of truth goes beyond what finite science in itself can discover. So one might argue for: **(1)** testing as many as possible of the Bible's statements or ideas (including religion "experiments," as well as tests against archaeology, internal harmony, etc), thus moving any that might be falsifiable into the realm of science; **(2)** via the weight of evidence thus accumulated, deciding with respect to the rest of Bible statements (which may not be subject to falsification), and hence the Bible paradigm itself; **(3)** acting on that decision.

#5

Text (p 18): Weight-of-evidence testing asks if the crucial falsification experiments, taken as a whole, heavily support one theory or paradigm over another. The outcome could provide confidence for acceptance (or denial) — and thus a secure enough understanding of **nature** for real-life usefulness. It would be a firmer basis for pleasure or application. Further, while much of **nature** (for example, mind or beauty or free will) is hardly subject to a falsification approach, and hence by definition is metaphysical, the untestable part *could* nevertheless be accepted or rejected on the basis of the weight of evidence for a whole paradigm.

Note: For specific application here, replace each **"nature"** with "the Bible" in the above text paragraph.

#6

Text (p 19): The weight-of-evidence method could open up a larger realm of nature or religion — whether as source of ideas, or of a whole body of belief,

to test. It could facilitate intelligent (vs blind) choice of a belief system that would bring ultimate meaning to life.

Notes: **(1)** The importance of a rational way to include ultimate meanings like beauty or moral responsibility, urges a search for the best paradigm that incorporates them. The weight-of-evidence method of evaluation proposed here should help. **(2)** If the Bible paradigm includes origin by creation, one might consider the possibility a) that things like moral absolutes are built into man's very physical being, and/or b) that they are continually imparted. **(3)** Refusing to choose short of certainty, is morally passive "in a world desperate for moral courage."[1] Here lies the value of doing what truly good science does: choose and act on the best supported (vs absolutely certain) position.

APPENDIX II. HASEL'S ANALYSIS OF KUHN'S PARADIGM PHILOSOPHY

The aim in my present paper was **not** to directly evaluate Kuhn's concept per se, but rather to see how the paradigm idea might be useful (or detrimental) in science or religion research. Hasel (1992),[2] on the other hand, **does** examine Kuhn's philosophical contributions and limitations.

Limitations Suggested by Hasel

Hasel points out the value of Kuhn's paradigms. But he also sees problems: (1) For judging paradigms, ***there is no* standard *higher than the assent of the relevant community***, and hence (2) ***no way to assure getting closer to ultimate* truth** *via changing paradigms*.

Kuhn assumes naturalistic metaphysics, thus (3) *l**imiting the* source *of ideas** *to test*. But God can act in *supernatural* ways, too. A Christian paradigm accepts God, through revelation as given in the Bible along with the historical evidence also given there.

Kuhn subscribes to the common belief of evolutionary origin (see near the end of his last chapter). *Evolutionary logic* (interpreting the past by comparison with the present, rather than by actual history) (4) ***undermines the normative use of* history** (use of history to establish a norm or standard). But the Bible is based on the interaction of God with history.

How Might These Limitations Be Counteracted?

Granting such problems, how could one still profit from the paradigm concept? The main body of my paper suggests (1) *an external* **standard** (that is, a criterion for evaluation) for paradigms, namely, "weight of evidence." Further, it suggests Popper's falsification approach as a rigorous way to improve the quality of evidences making up that weight.

For Popper, any metaphysical (including supernatural) idea is admissible as (3) ***a source*** *of ideas or hypotheses* (*if* falsifiable). Hence the Bible could be included as a source, much of it testable. And if it survives sufficient falsification tests to build up a high weight of evidence,[3] the Bible could become an external standard — rather than simply the internal assent of a particular human community. (This is not to ignore a role of direct divine guidance, *not considered here*.)

Thus by weight of evidence one could choose paradigms (for example, one consistent with the Bible) by Kuhn's (paradigm/scientific revolution) method. They would be paradigms with more than science sources of truth considered, opening (2) ***the way to get closer to*** **truth** via changing paradigms. Further, one could use this method to test the creation-Flood premise of the Bible, instead of an evolution premise, thus (4) ***making normative use of the*** **history** in the Bible.

In summary, a *comprehensive use of evidence* could facilitate

- making a choice between a naturalistic and a naturalistic + supernaturalistic paradigm; and/or
- using the best of paradigm and falsification concepts for their value in improving science or religion. Too often has religion been thought to be immune from evidence.

APPENDIX III. TRIAL OF A TEST WITHIN A BIBLE PARADIGM
(New American Standard Bible used for all Bible texts)

Rationale

How might one even begin to evaluate a belief system (here, a Bible paradigm) that is often considered too metaphysical for test? As often suggested above (see, for example, Table 1), a paradigm might be evaluated by the proportion of its hypotheses which pass falsification tests (that is, by *weight of evidence*). Another possibility would be to check for *internal consistency* — the *only* way the paradigm is evaluated here.

But there are different Bible paradigms. One that takes the Bible more directly than others would lend itself to more direct test, and is used here. Significantly, the Bible itself invites this: "Test Me now in this [promised blessing]" (Mal 3:10). "Examine everything carefully" (1 Thes 5:20-21).

This particular trial involved Bible instructions on *how to live*: did "prosperity" truly depend on following the Bible God? Replicates were persons who *did* vs those who *did not*.

For such an internal-consistency test, one must enter into the paradigm enough to consider the Bible dependable in its factual details. Faults of both good and bad people are expressed more frankly than in most biographies, thus facilitating the test.

Design of the Test

Hypotheses

A basic hypothesis central to this evaluation is that people truly committed to the God of the Bible "prospered" more than those not so committed. The hypothesis (divided into two, "material" and "spiritual" prosperity) would be falsified if committed persons failed to prosper (or if *un*committed *did* prosper). The outcome of the test might also be used to examine the question of universal application across the vast expanse of history or culture (for example, is the God of the New Testament the same as the God of the Old? or from one civilization to another?)

Variables (see also Special Notes below)

Material Prosperity (dependent variable): Idea of pleasure from physical good things, or honor or position conferred by other people, whether eternal or not.

Spiritual Prosperity (dependent variable): Idea of ultimate or eternal well-being: was person translated (like Elijah) or resurrected (like Moses) to heaven? included in "honor roll" list of Ez 14:20 or Heb 11?

Commitment (independent variable): show active interest in learning more about God? follow instruction with respect to accepting/obeying Him? repent after failures in this? In sum, *ultimate* commitment is what the Bible sees as important. As for other variables, objectivity here required strict limitation to evaluations or biographical details actually given in the Bible.

Replicates

Persons with enough Bible information given, and that lend themselves to direct pairing with others. Such pairing reduces observer bias, by using all (with enough data) in a given sub-group, rather than just the first that happened to be chosen. And if more analysis were desirable, matching within these subgroups could reduce differences due to other than the *primary* variables of interest. Table 2 gives the basis of grouping for Tables 3 and 4.

Are Bible Records Biased Toward Examples that Meet Prediction?

Since the very nature of Kuhn's paradigm may include bias within the community, how about bias in Bible authorship?

That would seem unlikely because frankness itself is so typical of Bible accounts mentioning bad as well as good traits of some of the best people. Further, the paradigm frankly pictures a God who greatly respects free choice, even though at the risk of being misunderstood (for example, as being easy on evil).

But even if the Bible were biased toward cases where outcome fitted prediction, the biographical examples were by so many different *authors*, in such different *cultures* or *circumstances*, and over so many *centuries* (more than a

millennium) that we still might expect significant discord. So a test of internal harmony is in this *second* sense independently valuable.

Special Notes on the Bible Paradigm

Promises and Conditions of Prosperity

Nowhere are these better laid out than in Deuteronomy 28.

But that chapter at least partly concerns a nation as a whole (v 1,9,13). The following texts clearly refer to *individuals*:

> *Honor your father and your mother that your days may be prolonged in the land which...God gives you* (Ex 20:12).
>
> *If you [Solomon] will walk before Me...in integrity..., doing.. all...I have commanded,...then I will establish.. your kingdom* (I Kgs 9:4-7).
>
> *How blessed is the man who does not walk in the counsel of the wicked,...nor sit in the seat of scoffers! But his delight is in the law of the Lord...in whatever he does, he prospers. The wicked are not so, but they are like chaff which the wind drives away* (Ps 1:1-6).
>
> *Because he has loved Me,...I will deliver him....He will call upon Me, and I will answer him; I will be with him in trouble* (Ps 91:14-16).
>
> *God so loved the world that He gave His only begotten Son, that whoever believes in Him should...have eternal life* (Jn 3:16).
>
> *Not every one who says to Me, 'Lord, Lord,' will enter the kingdom of heaven; but he who does the will of My Father.... Many will say ... 'Lord, did we not prophesy in Your name?'...I will declare to them, 'I never knew you; depart from Me, you who practice lawlessness'.... Every one who hears these words of Mine, and acts upon them, may be compared to a wise man, who built his house upon the rock....The floods...burst against that house; and yet it did not fall....Every one who hears these words...and does not act upon them, will be like a foolish man, who built his house upon the sand....Great was its fall* (Mt 7:21-27).

Note how opposite are the promised results. A fundamental condition is seen to be *commitment* for or against God: He strongly supports "those whose hearts are completely His" (2 Chr 16:9). David made gross mistakes, but always repented and would talk with God about it. (But Saul, the preceding king of Israel, justified himself.) Peter denied Jesus, against previous promise; but tearfully repented. (But Judas who long planned to betray Jesus, hung himself afterward.) (See Tables 3 & 4 below.)

Seeming Lack of Fulfillment: Material vs Spiritual Prosperity

A test of internal harmony of a paradigm would require use of the Bible's *own* criteria for prosperity. In accord with those listed above, the Bible portrays a law-abiding universe:

TABLE 2. Replicates used in Tables 3 and 4, to suggest relationship within each group of 2 or 3 persons — for example, same family, same time and/or place in history, similar experience, mutual contact.

CAIN/ABEL: Brothers in direct contact.

NOAH/Any one of REST OF WORLD: They were exposed to his Flood prophecy for 120 years.

SARAH/LOT'S WIFE: Wife of Abraham/wife of his nephew & close associate. JACOB/ESAU: Twin brothers in direct contact early & late in life.

JOSEPH/JUDAH: Brothers in direct contact early & late in life.

JOB/JOB'S FRIENDS: In direct conversational contact.

JOCHEBED/RAHAB: Mother of leader to Canaan/Canaanite woman who helped Israel enter there.

PHARAOH/MOSES/BALAAM: Moses had been heir to throne of Egypt & Pharaoh was in fact king at time of their direct confrontations; later Balaam was hired to curse very people Moses led out of Egypt.

2 SPIES (either one)/OTHER 10 SPIES (any one): The 12 (1 from each tribe) went on a 40-day trip to spy out Canaan.

SAUL/DAVID: 1st & 2nd kings of Israel, in much mutual contact.

SOLOMON/ABSALOM: Brothers; first was to be king after his father David, second tried to become king instead.

JEZEBEL/AHAB/ELIJAH: King Ahab & wife Jezebel were repeatedly warned by prophet Elijah.

DANIEL/BELSHAZZAR: Daniel had been prime minister of Babylon, later was in direct mutual contact with King Belshazzar.

JOHN THE BAPTIST/HEROD ANTIPAS/HEROD AGRIPPA: Antipas & John, as ruler & subject, had direct encounters with each other; Agrippa was nephew of Antipas & replaced him as ruler.

THIEF/PILATE/CAIAPHAS: All in direct conversational contact with Jesus at time of crucifixion.

JOHN/PETER/JUDAS: Each was one of Jesus' 12 disciples; John & Peter both were Bible writers.

> *'Let there be light';...God saw that the light was good.... The heavens are telling of the glory of God....The law of the Lord is perfect....I am fearfully and wonderfully made....He declared to you His...ten commandments* (Gn 1:3-4; Ps 19:1,7; 139:14; Dt 4:13).

People would function superbly in accord with these laws, but were given complete freedom to choose for or against:

> *I have set before you life and death.... So choose life ... by loving the Lord ..., obeying ..., holding fast to Him. If it is disagreeable ... to serve the Lord, choose for yourselves today whom you will serve.*

> *If the Lord is God, follow Him; but if Baal, follow him* (Dt 30:19-20; Jos 24:15; 1 Kgs 18:21).

Central to the paradigm is seen a great conflict between God and His enemies who (in spite of repeated appeals) turn Him down. *Material* prosperity alone would be an insufficient criterion of the validity of Bible promises. This is made clear by one struggling with the problem:

> *I was envious...as I saw the prosperity of the wicked....They are not in trouble as other men....Always at ease, they have increased in wealth....When I pondered to understand..., it was troublesome in my sight until I...perceived their end...utterly swept away by sudden terrors!...Those who are far from Thee will perish....Be not envious toward wrongdoers, for they will...be cut off, but those who wait for the Lord...will inherit the land....Better is the little of the righteous than the abundance of many wicked* (Ps 37:1-2,9,16; 73:3,5,12,16-17,19,27).

Thus material prosperity could be minimal or delayed, but *spiritual* (ultimate, eternal) prosperity could begin here and now.

A primary reason for this is that Satan deliberately brings bad things on good people (sometimes good things on bad people), as far as permitted: "The Lord said to Satan, '...All that [Job] has is in your power, only do not put forth your hand on him.' So Satan killed his herds, servants, and children" (Jb 1:12-19).

God, on the other hand, brings good things: "The Lord restored the fortunes of Job,...increased all that Job had twofold" (42:10).

Similarly, Jesus said, "you will be hated by all on account of My name, but it is the one who has endured to the end who will be saved" (Mt 10:22). One who goes all out for Him will receive many things now, *but* "along with persecutions; and in the world to come, eternal life" (Mk 10:29-30).

> *These died...without receiving the promises, but...having welcomed them from a distance, and having confessed that they were...exiles on the earth..., seeking...a* [heavenly] *country* (Heb 11:13-16).

They were even willing to do without material prosperity in order to gain spiritual prosperity.

Results

The Bible data (with text sources) are tabulated for the variables (across the top margin) and replicate persons (down the left margin) in Table 3 following.

Conclusions from the Test Results

See Table 4 for analysis of Table 3. Note that some of the positive/negative decisions in Table 4 were limited by amount or type of data; and further, that

TABLE 3. This listing shows just the first two and last two of the 37 individuals analyzed, to illustrate the method used. Commitment: as shown by fundamental direction of loyalty to or against God. Material Prosperity: in present temporary 'secular' sense. Spiritual Prosperity: in eternal sense, whether actually in present time, or after a resurrection; recognized by personal indication of relation to God, or by evaluation by Jesus or others.

NT = New Testament

	COMMITMENT	MATERIAL PROSPERITY	SPIRITUAL PROSPERITY
CAIN	Counterfeit offering angry at God; killed brother; no repentance (Gn 4:5-10,13-14)	Sad when offering not; accepted; ground cursed; so harder work; fear of murder	God refused offering; condemned when rejected plea; NT warning (Gn 4:5-12; 1 Jn 3:12; Jude 11)
ABEL	By faith gave proper offering (Gn 4:4; Heb 11:4)	Killed (Gn 4:8; Mt 23:35)	God accepted offering; Jesus called righteous; Heb 11 honor roll (Gn 4:4; Mt 23:35; Heb 11:4)
PETER	Left all to follow Jesus; made impulsive mistakes; denied Him but repented in sorrow; boldly defended Him; rebuked by Paul; looked to new earth (Mt 4:29-31; 16:21-23; 26:69-75; Mk 14:37; Lk 5:11; Jn 6:68; 18:10-11; 21:15-22; Acts 3:12-26; 5:29-32; Gal 2:11-14; 2 Pt 3:13)	Given great hauls of fish; got to see Moses & Elijah; jailed; killed, as foretold by Jesus (& described in secular history) (Mt 17:1-4; Lk 5:9-10; Jn 21:6, 18-19; Acts 4:3; 2 Pt 1:14)	Give miraculous power; Bible writer; enjoyed assurance of Jesus (Acts 3:6,12; 9:33-41; 1 Pt 1:1; 2 Pt 1:1, 16-19)
JUDAS	Stole funds; under Satan, betrayed Jesus; admitted guilt; suicide instead of repenting (Mt 27:3-5; Lk 22:3-6; Jn 12:6; Acts 1:16-18)	Given special place as treasurer for disciples; hanged himself (Mt 27:5; Jn 13:29)	Agony from betraying Jesus; "wicked," gave up "apostleship" (Mt 27:3-5; Acts 1:17-22,25)

the following conclusions are based on correlation - a preliminary type of evidence.

It can be seen that *spiritual* prosperity was related to commitment in all cases (46/46) (all the committed prospered and none of the noncommitted

TABLE 4. Summarized from evidence in Table 3.

NAME	EARLY						LATE(R)		
	C	MP	SP	C	MP	SP	C	MP	SP
CAIN				-	-1	-1			
ABEL				+	-	+1			
NOAH				+	-	+1			
REST OF WORLD				-	-1	-1			
SARAH				+	+1	+1			
LOT'S WIFE				-	-1	-1			
JACOB	+	±	+1				+	+1	+1
ESAU	-		-1				-	+	-1
JOSEPH	+	±½	+1				+	+1	+1
JUDAH	-	-1					+	+1	+1
JOB	+	-	+1				+	+1	+1
JOB'S FRIENDS	-	-1	-1				+	+1	+1
RAHAB				+	+1	+1			
JOCHEBED				+	+1	+1			
MOSES				+	-	+1			
PHARAOH				-	-1	-1			
BALAAM				-	-1	-1			
2 SPIES				+	+1	+1			
10 SPIES				-	-1	-1			
DAVID	+	±½	+1				+	±½	+1
SAUL				-	-1	-1			
SOLOMON	+	+1	+1	-1	-1	-1	+	-	+1
ABSALOM				-	±½	-1			
JEZEBEL				-	±½	-1			
AHAB				-	±½	-1			
ELIJAH				+	±½	+1			
DANIEL	+	+1	+1				+	+1	+1
BELSHAZZAR				-	-1	-1			
JOHN THE BAPTIST				+	-	+1			
HEROD ANTIPAS				-	+	-1			
HEROD AGRIPPA				-	-1	-1			
THIEF ON CROSS				+	-	+1			
PILATE				-	-1	-1			
CAIAPHAS				-	-1	-1			
JOHN				+	±½	+1			
PETER				+	±½	+1			
JUDAS				-	±½	-1			
TOTAL				20½/20		29/29	6½/9	9/9	
GRAND TOTAL	5½/8	8/8		26/37		37/37	32½/46	46/46	

A + or - represents a positive or negative commitment or prosperity: for commitment (C), what is seen to be basic or ultimate commitment; for material prosperity (MP), 'net' prosperity (both + & - if necessary); for spiritual prosperity (SP), especially what is judged to be final or ultimate prosperity. In MP and SP columns, 1 = positive correlation with C (½ = halfway correlation); note that it is much less for material than for spiritual prosperity. For some, separate columns show early and late(r) parts of life. Horizontal red lines separate matched groups of 2 or 3 persons. Blue = persons; Red = cases.

prospered). Evidently the promises for or against spiritual prosperity could be depended on.

Material prosperity was about 70% related to commitment, whether in terms of cases (32½/46, counting early and late segments of life as separate cases); or of persons (26/37, counting the most mature segment if both an early and late segment given). (To put it another way, more than half of the committed prospered; more than half of the noncommitted did not prosper.) This suggests a partial internal harmony of paradigm, but not the 100% seen for the spiritual prosperity.

Are then God's promises for material prosperity less dependable than for spiritual? Further analysis suggests a different answer. The Bible says clearly that material prosperity may be deferred until the end. To fully demonstrate the nature of *Satan's* kingdom, he is allowed to work, thus adding to the evidence needed to freely decide for or against God's universe. The Bible presents Satan as a hater of all good, and one would expect him to remove material prosperity from God's followers as far as allowed (or else give it to the disloyal, so as to confuse). But he cannot remove the *spiritual* prosperity promised if one decides for God.

Once the Bible's own definition of prosperity and the conditions for attaining it are understood, the correlation that really counts (that is, spiritual prosperity) appears high indeed. Thus, ***within such limitations as stated in the first paragraph above***, one may conclude that the paradigm survives *this particular test* of internal consistency. Actually, given Satan's challenge to God as pictured in the Bible, and God's respect for free choice, it may be remarkable that even the correlation between *material* prosperity and commitment could be as high as it seemed to be. In fact, the very complexities of the paradigm — more than one type of prosperity, total freedom of choice — give more meaning to the outcome of the test.

Is there bias in God's choice of what biography to include? As mentioned under **Design** above, there is reason to consider it unlikely. If there were such bias, it would not invalidate the evidence for internal harmony, but might rather explain the source of the harmony in terms of a God who is deceitful (hence directly opposite to the whole body of Bible teachings).

Further, the analysis used above to test for commitment/prosperity harmony can also be used to test for internal harmony in *another, quite different, sense*: One would expect almost inevitable discord from the enormous spans of author variable, culture/circumstance variable and time-era variable. But judging by the high correlations just described from Table 4, the examples seem relatively free of this type of discord as well - another evidence of internal consistency. In summary, this trial was limited in scope, and took for granted a paradigm belief that Bible biographies are factual. It found high consistency (1) of outcome with commitment, and (2) across the vast span of author, circumstance and era - both (1) and (2) unexpected unless there were high internal harmony of paradigm.

For comparison with another religious paradigm, one could make a similar analysis of that paradigm (of the Koran, for example). Or external tests could be made in such areas as archaeology. But the purpose here was rather to design and carry out one trial of the possibility of evaluating a non-science paradigm.

As it turned out, even deciding what should be replicates and independent or dependent variables was more demanding than expected. Development of Tables 3 and 4 was as objective as possible, limiting examples to those where the Bible itself made the evaluations or gave sufficient life-history data. The outcome was not known until the last, and demanded yet more thought as to the meaning of the 'prosperity' variables.

There is no final experiment, but trial after trial, improvement after improvement. It is easy to agree that "sometimes getting close is as close as we are ever going to get."[4]

ENDNOTES

1. Taylor D. 1986. The myth of certainty. Waco, TX: Word Books (also Zondervan 1992 reprint).
2. (a) Hasel FM. 1992. Thomas Kuhn's revolution: a new way of looking at science. Dialogue 2:11-13. Also pertinent: (b) Roth AA. 1988. Truth — an endangered species. Origins 15:49-51; and (c) Roth AA. 1990. What is happening to the philosophy of science? Origins 17:3-7.
3. There is one religious writer who repeatedly emphasizes a weight-of-evidence approach; for example, "God designs that men shall not decide from impulse, but from weight of evidence." (White EG. 1898. The desire of ages. Mountain View, CA: Pacific Press Publishing Assn., p 458.)
4. Speakman JR, et al. 1993. Physiological Zoology 66:1049, on the problem of finding animals diverse enough to differ taxonomically, yet alike enough for comparative studies.

ANNOTATIONS FROM THE LITERATURE

EVOLUTION

Brooks DR, McLennan DA. 1993. Macroevolutionary patterns of morphological diversification among parasitic flatworms (Platyhelminthes: Cercomeria). Evolution 47:494-509.

Summary: Parasites have traditionally been considered to exhibit morphological degeneration. Brooks and McLennan challenge this interpretation for parasitic flatworms (flukes and tapeworms). Cladistic methodology was used to analyze character transformations in parasitic flatworms. Free-living flatworms were not included in the analysis. Results of the study indicated that character loss amounted to slightly more than 10% of the inferred character transformations. The conclusion was that these parasitic flatworms are not unusually degenerate, but are better described as specialized.

Comment: The conclusions in the study are based on the assumption of common ancestry for all parasitic flatworms, a conclusion that should be independently investigated. The authors suggest that some parasitic flatworms may actually be more complex than some free-living flatworms. This may raise the possibility that these parasites are not simply degenerate derivatives of free-living flatworms, but may be designed to be parasites or commensals. The addition of free-living flatworms to the study would add interest to the results.

Carroll RL, Currie PJ. 1991. The early radiation of diapsid reptiles. In: Schultze H-P, Trueb L, editors. Origins of the higher groups of tetrapods. Ithaca and London: Comstock Publishing, p 354-424.

Summary: Species are classified into groups on the basis of uniquely shared characteristics. Shared characteristics may be interpreted as due to common ancestry or to convergence. Convergence is inferred when two groups share a similar characteristic that is thought to be not due to common ancestry. Convergence confuses the evolutionary interpretation of shared features, causing inconsistencies in the pattern. But convergence is a common problem in evolutionary

studies, often producing numerous inconsistencies in proposed evolutionary trees.

Comment: Reptiles have been divided into subgroups, one of which is Diapsida. This group includes lizards, snakes, crocodilians, sphenodontids, dinosaurs, and several other extinct groups. Diapsids first appear in Upper Carboniferous strata, but are relatively rare in Paleozoic sediments. The number of groups of diapsid fossils increases as one moves upward through the geologic column. As additional groups are included, the number of uniquely shared characteristics decreases, apparently due to convergence. Another pattern resulting from including additional groups of fossils is the increasing difficulty of comparing structures (determining homology). Carroll calculated that 70% of the character traits examined in his study exhibited convergence. This means that only a minority of character traits show patterns consistent with the hypothesis of common ancestry for this group.

Dawson A, McNaughton FJ, Goldsmith AR, Degen AA. 1994. Ratite-like neoteny induced by neonatal thyroidectomy of European starlings, *Sturnus vulgaris*. Journal of Zoology, London.

Summary: Ostriches and several other types of large flightless birds are collectively known as "ratites." In addition to being large and flightless, ratites share certain other morphological traits, such as features of the palate, unfused skull sutures, persistence of downy, juvenile type feathers, and an unkeeled sternum. These shared features are similar to those seen in juvenile birds, and it has been suggested that some of the ratites may have independent ancestries.

In the experiment reported in this article, the thyroid glands were removed from hatchling starlings at the age of four days. The affected birds showed delayed maturation, including slowed sternum growth, slowed development of feathers, undeveloped palatine bones and unfused skull sutures. In contrast to ratites, the affected birds did not grow as large as normal. Sexual maturation was accelerated, resulting in neoteny (the retention of early features into adulthood). Future studies will examine thyroid function in ratites.

Comment: In their present distribution, ratites are confined to the southern continents. This has often been interpreted to support the plate tectonics model of biogeography. However, some paleontologists have expressed doubts that ratites are related. If the ratites are simply neotonous forms lacking a common ancestry, the biogeographical

argument is invalid, as is suggested by some fossil and molecular evidence.

GENETICS

Farabaugh PJ. 1993. Alternative readings of the genetic code. Cell 74:591-596.

Summary: The genetic code has been known for twenty years or so. The code is based on groups of three DNA nucleotides (a codon), which either codes for a specific amino acid or is a start or stop signal. By determining the DNA sequence of a gene, one is theoretically able to predict the amino acid sequence of its product. There are some complications to this standard scenario. Intervening sequences (introns) are well-known, in which portions of the messenger RNA are spliced out before decoding and protein synthesis begins at the ribosome.

Comment: There are other rare phenomena that indicate the potential for altering the conventional message of a DNA sequence during the process of decoding. For example, termination codons are sometimes ineffective in stopping the cell from continuing to add amino acids to the protein being manufactured. Thus a codon that appears to be a stopping point may not function as a stopping point. Another unusual observation is frameshifting. In this situation, the predicted grouping of nucleotides into codons is altered so that the message is read in a completely different way. A third type of alteration is hopping, in which large DNA segments may simply be skipped. These observations indicate that the operation of the genetic system is much more complex than a simple understanding of the genetic code would indicate.

Hall BG. 1994. On alternatives to selection-induced mutation in the Bgl operon of *Escherichia coli*. Molecular Biology and Evolution 11:159-168.

Summary: The assumption that mutations were random was challenged in 1988 by experiments that appeared to show that mutations occurred more rapidly than expected under conditions favoring the mutant phenotype. The suggestion that mutations might somehow be directed touched off a controversy that has not yet been resolved. Other researchers challenged the conclusion that mutations may be directed, reporting tests that explained the previous results without recourse to directed mutation.

Comment: In this paper, Hall expands the experimental protocol to include tests of his own previous interpretations as well as those of his challengers. The mutation in question involves excision of a movable element, resulting in the ability of the cell to utilize the sugar salicin. Hall provides an explanation for his own previous results, his present results, and those of his challengers that involves directed mutation, and concludes that mutations may be directed, contrary to conventional wisdom.

GEOLOGY

Armitage MH. 1993. Internal radiohalos in a diamond. American Laboratory 25:28-30.

Summary: Radiohalos are cross-sections of spheres of crystal damage caused by radioactive decay. Over 75 radiohalos are visible in a small (0.012 g) diamond at magnifications of 125x - 250x. Since most diamonds are not examined at such high magnifications, it is uncertain to what extent radiohalos are found in other diamonds. The radiohalos have up to four visible rings, corresponding to the U-238 decay series. The U-238 ring itself is missing in all these halos. The visible rings include those of Ra-222, Po-218, Po-214 and Po-210. All of these isotopes have short half-lives, on the order of days or minutes. This suggests that either the diamond formed rapidly or was penetrated by a fluid containing radioactive atoms. The formation of diamonds is still not well understood, a situation made more complicated by the discovery of these radiohalos.

Comment: The origin of the radiohalos in these diamonds is another issue of interest. The radiohalos are similar to those often associated with uranium-bearing granitoid rocks. Their origin has been the subject of controversy, but may be the result of high-pressure transport of fluids containing products of uranium decay.

MOLECULAR PHYLOGENY

Amemiya CT, et al. 1993. VH gene organization in a relict species, the coelacanth *Latimeria chalumnae*: evolutionary implications. Proceedings of the National Academy of Sciences 90:6661-6665.

Summary: The coelacanth is sometimes considered to be the closest fish relative to land animals. Many have hoped that the characteristics

of this lobe-finned "living fossil" might provide some insight into the evolution of the tetrapods. However, this hope has not materialized. The arrangement of immunoglobulin genes in the coelacanth differs from that in any other known group. Like sharks and skates, the V_H (variable-chain heavy region) and D (diversity) elements are adjacent. Like bony fishes and mammals, the coelacanth has a V_H transcriptional octamer, V_H elements close together, and presumably many pseudogenes.

Comment: In an evolutionary scheme, these characteristics would indicate that tetrapods are more closely related to teleost fishes than to the coelacanth, contrary to the most popular hypotheses of evolutionary relationship.

Janke A, Feldmaier-Fuchs G, Thomas WK, von Haeseler A, Paabo S. 1994. The marsupial mitochondrial genome and the evolution of placental mammals. Genetics 137:243-256.

Summary: The entire mitochondrial genome of the American opossum has been sequenced. Two major differences with placental genomes are noted. First, the sequence of five tRNA genes is different. Second, the aspartic acid tRNA has an anticodon not normally found in the mitochondrion. Eight of thirteen mitochondrial genes are said to exhibit clocklike divergence rates. Lineage divergences based on these genes and calibrated against the geologic time-scale indicate a date of 35 Ma for the divergence of the closely related rat and mouse, compared with 41 Ma for divergence of cow and whale.

Comment: These results reveal a large discordance between morphological and molecular measures of similarity. Rats and mice are classified in the same Family, while cows and whales are classified in different Orders. Perhaps molecular sequences are not necessarily giving us an accurate picture of ancestry.

ORIGIN OF LIFE

Barbier B, Visscher J, Schwartz AW. 1993. Polypeptide-assisted oligomerization of analogs in dilute aqueous solution. Journal of Molecular Evolution 37:554-558.

Summary: The source and polymerization of nucleotides is a major unsolved problem for origin-of-life models. One proposal is that a series of chemical reactions developed into a self-sustaining cycle of

nucleic acid production. In this hypothetical autocatalytic cycle, template nucleic acid molecules would form a pattern which would be copied by a replicate nucleic acid molecule. This hypothesis has been bolstered by the production of purine polynucleotides up to 40 units in length, using a poly-C template. However, pyrimidine polynucleotides, such as the poly-C template itself, are more difficult to produce. Because of this, a purine-dominated template would not be a suitable template for the cycle to continue. This problem effectively prevents an autocatalytic system from forming. Without a preformed template, polymerizations produce very low yields. The authors attempted to get around this problem by adding polypeptides of leucine and lysine, rather than using a nucleotide template. This procedure increased the yield and oligomeric length of DNA nucleotide polymerization substantially.

Comment: This experiment advances our understanding of chemistry, but does not help explain the origin of life. The idea that ribonucleotides could somehow form in a primordial ocean full of chemical contaminants is highly implausible to begin with. No plausible source is identified for the polypeptides used in the experiment. In addition, the experimental conditions are implausible in a prebiotic world.

PALEONTOLOGY

Aberhan M. 1993. Faunal replacement in the Early Jurassic of northern Chile: implications for the evolution in Mesozoic benthic shelf ecosystems. Palaeogeography, Palaeoecology, Palaeoclimatology 103:155-177.

Summary: Differing geologic strata have different types of fossils. Paleontologists typically interpret such stratigraphic differences as the result of either evolution or migration. Evolutionary replacement would occur as newly evolved species replace their more poorly adapted ancestors. Ecological replacement would occur as environmental conditions changed, favoring migration of species from other areas.

Aberhan reports that ecological replacement is characteristic of Lower Jurassic benthic shelf faunas from northern Chile. His survey of the literature showed that ecological replacement is a common and widespread feature of Mesozoic benthic shelf fossil assemblages. "Evolutionary replacement" seems limited to restricted basins. Within-habitat species replacement seems controlled by "sea level fluctuations."

Comment: How would these patterns be interpreted in a flood model? Patterns interpreted as "ecological replacement" might result from a change in source area, or from taphonomic sorting. A sequence produced by such activity could produce a fossil sequence in which successive layers did not appear to have ancestral-descendent characteristics. Patterns interpreted as "evolutionary replacement" might be produced if the same source habitat or area were sampled in successive layers. Similar species generally live in proximity to each other, providing the potential for successive fossil samples to closely related. Differences could be due to taphonomic appear sorting, morphological gradients across a region, or ecological gradients across a region.

LITERATURE REVIEWS

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

A PICTURE WINDOW ON THE EOCENE

MESSEL: AN INSIGHT INTO THE HISTORY OF LIFE AND OF THE EARTH. Stephan Schaal and Willi Ziegler, editors. Monika Shaffer-Fehre, translator. 1992. Oxford: Clarendon Press. 322 p. Hardback, $85.00

Reviewed by Harold G. Coffin, The Dalles, Oregon

The outstanding preservation of animals and plants in the Messel pit warrants a volume that can do justice in illustrating these organisms, and this volume meets that challenge. It is a landmark for magnificent illustrations, most of them in color. Although technical details are well-represented in this volume, its main audience is the educated layperson or scientists in general. The volume is a symposium with various scientists addressing their areas of expertise.

Messel (often described as a pit or lake) is the name for a Middle Eocene site near Darmstadt, Germany. Quarrying in the past for oil shales has left a shallow depression, spanning less than one kilometer. In recent years Messel has been used as a landfill, but fortunately, this is no longer allowed, and its paleontological value has become recognized. A great array of plants and animals — marine, freshwater, and terrestrial — was buried and exquisitely preserved. Messel is considered to have been a lake with at least occasional access to oceanic waters. Although in some areas the fossil fish show orientation, in general there is no evidence of strong currents. The prevailing view is that the lake bottom was anoxic (without oxygen) at least part of the time.

Well-preserved leaves of 65 species of plants have been identified. The leaves, fruits, pollen, etc., indicate a tropical to subtropical climate. Puzzling is the absence of larger plant structures such as trunks, roots, and limbs. A number of the species are now limited to tropical areas of

Africa, Asia, or South America. Examples are "Milfordia," certain palms, fruits of Mistixiaceae, and certain pteridophytes. Caddis-fly larvae are abundant on certain fossil plant fragments such as lotus blossoms. Grape seeds were found in the stomach contents of a horse.

Insects are well-represented; in fact, the Messel pit is considered one of the best insect fossil sites of the world. Many of the beetles show their original colors. Giant ants with a wingspan of 126 mm, dung beetles, cockroaches (not common), crickets and stick insects, are represented. Many ants from several species have been found — all of them are, winged. Some insects are unusual, such as "Stylops," a small parasitic wasp found protruding between segments of an ant — the oldest example of this type of parasite-host relationship.

> *These finds are evidence not only that in the Middle Eocene the same parasite-host relationship already existed as exists today, but simultaneously, that we must assign a far greater age than has been usual to the entire order Strepsiptera [maggot-like insect], because the Myrmecolacidae are evolutionarily the youngest family. In addition, both of these finds are good indicators of a tropical-subtropical climate during the epoch of the European Middle Eocene* (p. 64).

The near absence of water insects, such as dragonflies and stone-flies, and the rarity of mosquitoes pose a challenge to the lake hypothesis.

All the fossil fish of Messel are "bony." Bowfin-like types, gars, perch, and many other kinds are present, including the "oldest" record of a freshwater eel. Because eels migrate to the ocean and back, Lake Messel, if a reality, appears to have been connected to the sea. An anomaly is the absence of any fossil fish other than predators, indicating an incomplete food chain. I was struck by the many illustrations of fossil fish with mouths open.

Amphibians are rare, which is an odd situation if Messel was a freshwater lake, since many amphibians spend most of their lives in freshwater. Only one specimen of salamander and three species of frogs and toads are represented. One of the toads (spade-foot toad) shows spawn, but no fossil tadpoles have been found.

The "first" fossil turtles are from the Triassic, but are not that different from the Messel turtles and, for that matter, modern turtles:

> *In the terrestrial tortoises, for example, the digits are very much shortened; in freshwater or oceanic turtles they develop,*

> *by elongation of the bony elements, into effective paddles. These characteristics have not changed essentially up to the present day and allow us to draw comparisons with extant chelonians [turtles, etc.]* (p. 101).

Six genera of crocodiles, most specimens of small size, have been excavated. Different species of modern crocodiles seldom co-exist. The presence of several genera and species in one small area suggests these animals were transported from different biotopes to Lake Messel. Other reptiles also are important and abundant. Surprising aspects are the unusual armored lizards, limbless lizards, monitor-like lizards (considered modern and advanced), and the earliest documented fossil snake. Speaking of the limbless lizards the authors say:

> *The already very highly evolved adaptations of Messel limbless lizards (which represent a largely 'finished' construction no longer undergoing fundamental development) make the appearance and the evolutionary origin of the ancestors appear all the more mysterious* (p. 123).

The Messel fossil birds are not much different from modern birds. Feathers are clearly seen on some of the fossils. Note this list of birds that have been collected through the years: falcons, ibises, seriemas, rails, flamingos, owls, swifts, and birds similar to ostrich, fowls, cranes, nightjars, rollers, woodpeckers, and others not well known. The birds suggest zoogeographical connections with North America, Africa, Asia, etc. The complete absence of true water birds at Messel is also incompatible with the lake model.

Many orders of mammals are represented. The only marsupials found are opossum-like. Concerning insectivores the following comment is made: "It appears remarkable to us that three mammalian species of such homogeneous and highly specialized type are able to share a habitat" (p. 164). Several hundred bats, including highly specialized forms, have been found. Even stomach contents, including one specimen that dined only on moths and butterflies, are identifiable. The suggestion is made that the sudden death of so many bats was the result of toxic gas over the water, but the absence of true water birds challenges that hypothesis. Four different primates, pangolins (scaly anteaters) and a South American anteater are oddities.

Speaking of carnivores at Messel, Springhorn says:

> *Among the mammals, there is a significant preponderance of finds that, according to their relaxed skeletal position and the degree of disintegration, must be regarded as having drowned* (p. 231).

Odd- and even-toed ungulates (having hoofs) are well represented. In fact seventy specimens of horses (including foals and pregnant mares) make Messel a prime fossil site for "primitive" horses:

> *Initially it was believed that evolution progressed in a straight line that led from primitive forms, with five small hooves on each extremity, to the Recent single-hoofed representatives, but we know today that the development has not proceeded so simply. At all times there were ramifications when evolution, mosaic-like, sometimes progressed more slowly, while at other times or in other parts of the body it proceeded more quickly. Sometimes one complex of characters evolved, then another. Again and again lines became extinct...*
>
> ...
>
> *If one could meet these small animals today [speaking of Eohippus=Hyracotherium], which ranged in size from that of a pekinese to that of a fox terrier, one would hardly recognize them as relatives of extant horses. On the front legs they still had four hooves, on the hind legs three each — in all 14 hooves! Legs and neck were still quite short and the back was still strongly curved, reminiscent of the extant duiker antelopes* (p. 243).

Perhaps they should not be called horses! The even-toed ungulates from Messel are already much more differentiated than was originally assumed.

Do the Messel remains represent life, death and burial under normal conditions, or are they the result of catastrophic geologic activity such as would be expected by a global flood? Some of the features which suggest normal or near-normal conditions are:

1. The localized accumulations of fossilized remains in what looks like an ancient lake.
2. The presence of some insect larvae attached to plant remains. Could these have survived the Genesis Flood?

3. Some evidences suggesting that some organisms could not have been transported far.
4. Fossil fecal pellets.

On the other hand, note these factors that indicate unusual conditions or contradict the lake model for Messel.

1. Excellent preservation of most plant and animal remains indicates rapid sedimentation.
2. The absence of remains expected in a small lake environment, such as herbivorous fish, roots, stems, and branches of trees and shrubs, water plants (except for water lilies), water insects (some exceptions), amphibians (rare exceptions), and true water birds.
3. The presence of some species now with limited distribution in tropical Africa, South America, Asia, or other areas far removed from Messel.
4. The presence of sea animals that require oceanic access to Lake Messel. Periodic opening and closing of the lake to ocean access without the lake being destroyed seems unlikely.
5. The relaxed position of many of the birds and mammals strongly suggests death by drowning rather than death under normal conditions.
6. Tropical to subtropical climate indicated by the fauna and flora.

Little mention is made of the elevational or stratigraphic positions of the various categories of plant and animal fossils. One might suspect that both flood and early post-flood activity is involved in Messel — perhaps late-flood deposits in the lower part and early post-flood in the upper layers — but further information and research are needed to clarify this suggestion. At any rate, the statement below, made by one of the authors, is apropos:

> *One of the most difficult problems of the Messel research, as always, still proves to be the construction of a valid model of Lake Messel itself* (p. 66).

I recommend this volume for anyone interested in paleontology.

LITERATURE REVIEWS

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HOW FINAL IS FINAL?

DREAMS OF A FINAL THEORY. Steven Weinberg. 1992. NY: Pantheon Books. 334 p. Cloth, $25.00.

Reviewed by Benjamin L. Clausen, Geoscience Research Institute

Steven Weinberg shared the 1979 Nobel Prize for Physics with Sheldon Glashow and Abdus Salam "for their contributions to the theory of the unified weak and electromagnetic interaction between elementary particles." This book describes the hope of Albert Einstein in his later years, of Weinberg, and of physics in general, to unify all of the forces of nature — gravitational, weak, electromagnetic, and strong — into one final theory (ch 10) that will provide a complete and beautiful (chs 5 and 6) basic understanding of the natural world. Although he states on p 5 that this "is not a book about the Super Collider" (i.e., the Superconducting Super Collider, or SSC), Weinberg devotes the final chapter (12) to the SSC, stating that "without it we may not be able to continue with the great intellectual adventure of discovering the final laws of nature" (p 274). Chapter 8 describes the current lull in the advance of physics that he hoped the SSC would overcome. Considering that Weinberg actively participated in planning the SSC until it was scrapped in 1993, it is not surprising that he takes several opportunities to justify building the multi-billion dollar accelerator.

Chapter 1 notes that "by the 1890s an odd sense of completion had spread to many scientists" (p 13), but this was a misguided perception considering the major revolutions in physics of this century. Lest the author be accused of hoping for that same kind of complete theory, he states that a final theory would "be final in only one sense — it will bring to an end a certain sort of science, the ancient search for those principles that cannot be explained in terms of deeper principles" (p 18).

Some of the physics details of the book are reviewed elsewhere (Wilczek 1993; Smith 1993); here some of the philosophical implications will particularly be addressed. Chapter 2 gives examples from physics, chemistry, biology, and astrophysics of the many scientific "arrows of explanation" that eventually converge to the four basic forces. Combining these four forces into one grand unified theory would provide the one final answer to all questions. Of course in practice, the theory would have the usual limitation for complex systems (such as the weather or living organisms) that slight inaccuracies in knowing the initial conditions result in total loss of predictive power over time. He concludes the chapter by saying:

> *... our discovery of the connected and convergent pattern of scientific explanations has done the very great service of teaching us that there is no room in nature for astrology or telekinesis or creationism or other superstitions* (p 50).

Other authors have suggested that a totally naturalistic world view is insufficient to explain all of the observed data from cosmology, quantum mechanics, complex systems, the conscious mind, and coincidences in the fundamental constants (e.g., Davies 1983; Gribbin & Rees 1989; Squires 1990; Pearcey & Thaxton 1994). However, Weinberg believes that a final theory will need only naturalistic components. Chapter 3 gives "two cheers for reductionism," argues that there are no fundamentally new laws for complex systems, and decries holism as the "nuttiest extreme" (p 53). Chapter 4 finds no "messages for human life in quantum mechanics that are different in any important way from those of Newtonian physics" (p 78). Probabilistic interpretations do not do away with determinism or make room for human free will and divine intervention. Chapter 9 mentions that the constants of nature presently appear to be well suited for the existence of life only by coincidence, with the dubious anthropic principle as their only explanation: what we can expect to observe must be restricted by the conditions necessary for our presence as observers. However, Weinberg believes that a final theory, perhaps some kind of string theory, would be able to prescribe values for all these constants of nature without any surprising coincidences, although he recognizes that a cosmological constant of exactly zero to 120 decimal places may still require some kind of anthropic principle for explanation. Finally, he says "it is consciousness that presents us with the greatest difficulty," but even there it "is not

unreasonable to hope that ... we shall be able to recognize something, some physical system for processing information, that corresponds to our experience of consciousness itself" (p 44-45).

Chapter 7 finds no use for philosophy in arriving at the final physical principles, and Chapter 11, entitled "What About God?", finds no place for theology either. Weinberg says that "the only way that any sort of science can proceed is to assume that there is no divine intervention" (p 247). As such "there is an incompatibility between the naturalistic theory of evolution and religion as generally understood" (p 248). The incompatibility is not one of logic, but of temperament. Religion didn't arise to answer questions about first causes, "but in the hearts of those who longed for the continual intervention of an interested God" (p 248). If no conflict is seen, "the retreat of religion from the ground occupied by science is nearly complete" (p 250). To try to resolve the conflict by having science treat factual reality, while religion treats human morality doesn't work. Weinberg goes on to state that religion as defined by the great majority of believers definitely has something to do with factual reality (p 249).

Weinberg would like to believe in a designer, but that designer would also have to be responsible for suffering and evil (p 250). He would like to find evidence in nature of a concerned creator, but finds "sadness in doubting that we will" (p 256). He does not think "that science will ever provide the consolations that have been offered by religion in facing death" (p 260). Religion provides meaning and hope, but for those very reasons it seems "indelibly marked with the stamp of wishful thinking" (p 255).

To respond, science has done well at mechanistically explaining the natural world, with a steadily diminishing need to invoke a god-of-the-gaps until its use has fallen into disrepute. But it has left humanity with a clockwork universe that provides nothing for the human spirit. Woe is the church if it provides no more than science for the basic needs of the human soul, if it provides only rules, creeds, doctrines, and rites, if it doesn't provide the concern of a friend or of a personal God who cares. The evil in the world can be explained philosophically by a God who made creatures with free will so they could love, but when evil directly affects a person's life, the only answer comes from a friend who can empathize, or a personal God who understands. A purpose in life requires the personal touch, making a difference in some-

one else's life. Weinberg feels that personal need, but unfortunately does not see the solution in religion.

Finally, Weinberg finds fundamentalists and other religious conservatives in one sense closer in spirit to scientists than religious liberals. Conservatives believe in what they believe because they think it is objectively true, whereas liberals "think that different people can believe in different mutually exclusive things without any of them being wrong, as long as their beliefs work for them" (p 257). However, "it is conservative dogmatic religion that does the harm" with "the long cruel story of crusade and jihad and inquisition and pogrom." Weinberg would like to strike a balance between the contributions of religion and its problems, but in so doing "it is not safe to assume that religious persecution and holy wars are perversions of true religion" (p 258).

These comments should be of concern for any group that feels it has a corner on truth, whether scientific or religious. Even objective truth can be viewed from many different perspectives with each individual attaching different relative significance to different aspects. Thus the fact of objective truth gives no license for one group to force its perception of that truth on others.

Weinberg does a good job of making a case for the beauty and power of naturalistic science. He catches the reader's imagination as he describes the hope for a final theory. Unfortunately, he pictures a totally naturalist theory with no place for God. Arguments are often on his side; the changed life of someone touched by the Person of God is not.

LITERATURE CITED

Davies P. 1983. God and the new physics. NY: Simon & Schuster.

Gribbin J, Rees M. 1989. Cosmic coincidences: dark matter, mankind, and anthropic cosmology. NY: Bantam Books.

Pearcey NR, Thaxton CB. 1994. The soul of science: Christian faith and natural philosophy. Wheaton, IL: Crossway Books.

Smith CHL. 1993. The particle connection. Nature 361(6414):697.

Squires E. 1990. Conscious mind in the physical world. NY: IOP Publishing.

Wilczek F. 1993. Weinberg: a philosopher in spite of himself. Physics Today 46(4):59-60.

GENERAL SCIENCE NOTES

CAN TREE RINGS BE USED TO CALIBRATE RADIOCARBON DATES?

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WHAT THIS ARTICLE IS ABOUT

Scientists correct the raw data from radiocarbon dating determinations so as to give what they consider to be a more accurate real-time age. This is necessary because of the uncertainty about the original concentration of carbon-14, which must be assumed to calculate a radiocarbon age. In order to determine what real-time age should be associated with a radiocarbon age, the radiocarbon data are often compared to historical and tree-ring data that are considered to be more reliable indicators of time. Tree-ring data are especially important in the correction process for dates older than 1000 BC. Extensive lists of correlation between radiocarbon data and tree-ring data have been published.

However there is a problem. It appears that the tree-ring chronology that has been established to adjust the raw carbon-14 determinations is a fragile structure. Our oldest living trees appear to be less than five thousand years old. Radiocarbon corrections beyond that are often based on attempts to match the thickness variations of tree rings in old wood samples. If a similar pattern of variation in tree-ring thickness is found in two pieces of wood, the two are assumed to have grown at the same time. By comparing many pieces of wood and combining matches, tree-ring chronologies of over 11,000 years extent have been proposed for use in correcting carbon-14 dates. The reliability of the system is dependent on the correctness of the tree-ring matches, — and here there is considerable uncertainty. Statistical tests show that it is easy to get significant matches of tree-ring patterns at various juxtapositions between samples of wood. More sophisticated statistical tests are being developed to correct for this problem. However, these tests were not used when the original dendrochronological correction scheme for carbon-14 dates was established. It appears that this original scheme is subject to reevaluation.

Using radioactive carbon (carbon-14 — C-14) to determine age is a complex process. The method is based on the slow disintegration of C-14. The less C-14 present in a sample, the older it will date. To determine a date, one must have data concerning:

1. the present content of C-14 in the specimen (determined as the ratio of isotope 14 to isotope 12 — C-14/C-12 —, or as the number of C-14 atom transformations per second per gram of carbon),
2. the rate at which C-14 spontaneously converts to nitrogen (N-14), and
3. the C-14 content — C-14/C-12 ratio — at the beginning of the time period related to the age.

At the best laboratories the C-14/C-12 ratio can be determined to about one-thousandth of the value that characterizes contemporary plants and animals. The most recent determination of the spontaneous C-14 conversion rate indicates that, within an uncertainty of about ± 30 years, in 5715 years half of an initial amount of C-14 will have converted into N-14.[1] At this rate of conversion approximately 57,000 years would be required for the C-14/C-12 ratio to diminish one-thousand-fold. The initial C-14/C-12 ratio is not accessible to experimental determination, and must be assumed. Accordingly, any C-14 age is based on an assumption.

The simplest calibration base for the initial C-14 is the assumption that throughout all past time accessible to C-14 dating, the C-14/C-12 ratio in the active carbon exchange system has been the same as it is at present. With this calibration base a specimen for which the C-14/C-12 ratio is 0.001 times that of corresponding contemporary material has a 57,000 year radiocarbon "age." Radiocarbon ages obtained in this simple, direct way may be classified as "radiocarbon isotope ages."

However, there is good evidence that the proportion of C-14 has varied over time, and a more reliable calibration base is the C-14/C-12 ratio found in artifacts that have a precise and accurate historical (calendric) age. A base established in this manner requires guessing by interpolation for C-14/C-12 ratios that fall between values that have been calibrated by historical dates. Also it is insecure for extrapolation beyond the oldest firmly established historical calibration points.

For older dates the most satisfactory calibration base is the C-14/C-12 ratio of wood that has been dated by dendrochronology.[2] In

temperate climates wood cells that are produced in the beginning of the growing season are larger and have thinner walls than the cells produced in the latter part of the growing season. The density difference between early and late growth produces visible features known as tree rings. Variation in the width of these rings results from year-by-year variation in the conditions favorable to growth of a particular portion of a tree.

By assuming that a similar variation in the pattern of ring thickness between samples represents growth during the same period of time, the ring-width patterns of many wood specimens can be combined into a single master dendrochronological sequence that 1) has an average growth-ring width variation pattern for periods of overlapping growth, and 2) extends the time range beyond the time span of any one component. Extension of the time range is accomplished by matching an upper portion of the ring-width sequence in one specimen with the lower portion of another specimen. The Bristlecone Pine master dendrochronological sequence that has been foundational for C-14 calibration has been based on 81 living-wood and 118 dead-wood specimens from the White Mountains of California.[3] This basic pattern for dendrochronological calibration of C-14 age was set by C. W. Ferguson in 1969.[4]

A calibration that falls within a time span that has been established by wood specimens that have been dated by unquestioned historical records (usually by cross-referencing C-14 ages) can be relied on to give a high precision estimate of real time. But because of the uncertainty in matching a wood specimen against a master sequence only on the basis of growth-ring patterns, there is uncertainty regarding the validity of a master tree-ring sequence in a range that has been extrapolated beyond an unquestioned historical reference point.

The magnitude of these uncertainties is indicated by tree-ring study of a Douglas fir log from a Mt. St. Helens pyroclast-flow deposit.[5] I am indebted to R. M. Porter for bringing this study to my attention.[6] The flow that contained this log has been dated by stratigraphy (dating of rock layers) to have occurred within the range AD 1482-1668. The log had 290 growth rings from core to bark. The age of the growth-ring immediately adjacent to the bark is designated as the “bark date.” Segments of 20 or more tree-rings beginning from either edge of this 290-ring sequence were compared for possible match against the Douglas fir master tree-ring sequence.[7]

Computer-calculated coefficients of cross-correlation statistically significant at or beyond the p=0.001 level (99.9% confidence) indicated

113 possible bark dates within the range AD 1410-*2240* (projected bark dates that are beyond the present are italicized). Forty-three of these matches were within the bark-date range AD 1483-1668, 23 within the range AD 1669-1771, and 47 within the future range AD *2078-2195*. Matches beyond the limits of the master chronology were made using a partial overlap with the 290-ring log. The AD *2195* date match had a 75 ring overlap with the AD 1980 end of the master-ring sequence. The lowest match, AD 1483, had an 87 ring overlap with the AD 1396 end of the master sequence.

Matches can be evaluated using the Student's-t statistical test of probability. The 113 matches had Student's-t[8] statistical values within the range from 3 to 7, the highest of which was 6.8 for an AD 1647 bark-date match. All these student's-t values suggest a high statistical reliability (99.9% confidence) under the assumptions with which the matches were made. The most secure interpretation of these data indicates tree-ring matches that place bark dates near the midpoints of the six AD ranges 1493-1510, 1642-1664, 1744-1748, 1756-1772, *2078-2098, 2172-2180,* for which Student's-t values greater than three are clustered.

To see the significance of these data, consider all the dates inverted from AD to BC, and the "bark date" an indication of the beginning rather than the end of a growth sequence. An investigator seeking to extend a tree-ring master chronology that had been developed to 1980 BC might get a match with the last 75 growth rings of a subfossil log containing 290 growth rings. This match could provide a high degree of statistical assurance for incorrectly extending his master chronology to 2195 BC. The investigator might not be aware of a better match possibility with a 1647 BC terminal date (extending growth period 290 years to 1357 BC).

An individual who used C-14 measurements for a guide in assembling a tree-ring sequence, as is often done, would be unlikely to make a single error as great as 215 years (2195-1980), but an accumulation of smaller errors is possible. Or, an investigator with an unknown-aged piece of wood containing 290 growth rings could with a high degree of statistical justification chose any one of 66 matches (113-47) within the previously developed master growth-ring sequence, making his ultimate choice in accord with where he had expected, or wanted, the match to occur.

Special procedures have been developed to reduce such errors. By a mathematical technique for "whitening" a master chronology sequence, i.e., removing the effects of correlated ring-width sequences within the master sequence (repeated patterns of variation — auto-correlation), Yamaguchi[9] was able to eliminate 112 incorrect matches and focus on the AD 1647 bark date. After the whitening process the cross-correlation for the AD 1647 date had a Student's-t value of 5.05 (greater than 99.9% confidence level), and a correlation coefficient of 0.29. (For a correlation coefficient of 1.00 the relative width of *each* of the 290 rings in the log would be exactly the same as the relative width of the corresponding ring in the master chronology.) These results confirmed stratigraphic placement of the volcanic eruption that buried the log within the AD 1482-1686 time range.

Whitening technique was not used in the development of the Bristlecone Pine master dendrochronology that is the standard for calibrating C-14 age. Whitening technique analysis of the various dendrochronology master sequences that were published prior to 1985 indicates that the master sequence developed by Ferguson has unique auto-correlation features, and that its use is definitely questionable.[10]

Matching a 290 growth-ring sub-fossil log to the Pacific Northwest Douglas Fir master growth-ring sequence is an ideal tree-ring dating assignment. If cross-matching is no more certain than in this example, what confidence is justified in the extension of a master tree-ring sequence beyond the range that is constrained by unquestionable historical records, since each stage in the extension of a master chronology is a cross-matching operation? Specifically, what statistical assurance does dendrochronology provide for presuming that C-14 isotope ages relate approximately 1:1 (within 10%) with real time between 500 BC and ~10,000 BC?[11]

ACKNOWLEDGMENTS

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ENDNOTES

1. CRC. 1994. Handbook of chemistry and physics. 75th ed. Boca Raton, FL: CRC Press, Section 11, p 36.

2. Long A, Kra RS, Devine JM, Stuiver M, editors. 1993. Calibration 1993. Radiocarbon 35(1).
3. LaMarche VC, Jr., Harlan TR 1973. Accuracy of tree ring dating of Bristlecone Pine for calibration of the radiocarbon time scale. Journal of Geophysical Research 78(36):8849-8858.
4. Ferguson CW. 1969. A 7,104-year annual tree ring chronology for bristlecone pine, *Pinus aristata*, from the White Mountains, California. Tree-Ring Bulletin 29(3-4):3-29.
5. Yamaguchi DK.1986. Interpretation of cross correlation between tree-ring series. Tree-Ring Bulletin 46:47-54.
6. Porter RM.1995. Correlating tree rings. Creation Research Society Quarterly 32(3):170-171.
7. See Note 5. Eight-hundred thirty potential bark dates (matches) of a 290-ring log against a 584-ring master sequence.
8. The Student's-t statistic provides an estimate of the degree to which a given set of data is representative, a measure of confidence that the data average represents the true value of the quantity it measures. See a textbook on mathematical statistics.
9. See Note 5.
10. Monserud RA.1986. Time-series analyses of tree-ring chronologies. Forest Science 32(2):349-372. Particularly see p 364.
11. Brown RH. 1994. Compatibility of biblical chronology with C-14 age. Origins 21(2):66-79.

EDITORIAL

THREE KINDS OF SCIENCE

A number of years ago I was reading the campus newspaper at a large university where I was a graduate student. My attention was focused on a book review — definitely no ordinary book review! Several professors had been contacted to comment on the book and some of the comments were not too complimentary. The problem was that this was an unconventional biology textbook which favored creation instead of evolution. One comment was to the effect that science could not be fitted into the impossibly narrow confines of the biblical account of beginnings. This statement appeared significant to me, because it implied that science was broader and more open than the defined conclusions of Scripture. A broader approach would have a greater potential of finding truth.

I continued reflecting on this question from several perspectives, and in the process began wondering if science could be fitted into the impossibly narrow confines of a naturalistic philosophy that arbitrarily excludes God and suggests an evolutionary origin of nearly everything. Even if God exists, would a science that excludes Him from its explanatory menu ever be able to find Him? Which discipline is impossibly narrow? It seemed to me that evolutionists had the right to accuse creationists of beginning with their conclusions; however, creationists had the right to accuse evolutionists of doing likewise. Who had the really impossibly narrow viewpoint?

The question raised is complex and is not easily resolved. Part of the problem is that there is no simple definition or understanding of what science is. Science is a broad concept that can be approached and understood from a variety of perspectives. Because of this we can divide science in various ways. Possible categories are natural sciences, social sciences, experimental sciences, and theoretical sciences. For the purpose of this discussion I would like to suggest three kinds of science: (1) naturalistic science, (2) creation science, and (3) methodological science. I am not especially enamored with these designations but will use them because they do convey somewhat the concepts represented.

Naturalistic science *reflects the modern philosophical understanding of science. It is a mechanistic approach to reality; explanations are based on our common understanding of cause and effect; God is ignored or does not exist. Evolution of the universe and of life is the only acceptable model of origins. It is noteworthy that much of man's study of nature (science) has not been conducted under the aegis of a naturalistic philosophy. A naturalistic science only gained broad acceptance a little over a century ago. The leading scientists who laid down the foundations of our modern science, such as Robert Boyle, Blaise Pascal, Carl von Linne, and Sir Isaac Newton, were much more like creation scientists than naturalistic scientists.*

Creation science *posits that there is a God who is the Creator, and the Bible is His word. Nature is interpreted in the context of that basic philosophical stance. Creation science is often treated with derision by naturalistic scientists, especially evolutionists who sometimes point out that the term "creation science" is an oxymoron. Creation is not considered to be a science, because creationists are starting with the conclusions of creation. On the other hand, it is not at all clear that evolutionists don't start with an evolutionary agenda as they interpret nature.*

I would like to suggest a third type of science, which for lack of a better term will be called ***methodological science****. This science focuses on science as a method of finding what nature is saying. As such it is free of the restrictions of either naturalistic or creation science. It is more open to find truth wherever the data lead, regardless of conclusions. It is subject to the logical conundrum that as soon as any philosophically significant conclusions are accepted, you no longer have an open system of inquiry. As with naturalistic and creation science, you can easily move into a thought pattern where further study will be influenced by the conclusions already drawn.*

We have mentioned three different approaches to the study of science, with objections to each. Which system is best for finding truth? First, it needs to be pointed out that a retreat into agnosticism or relativism is unsatisfying and unproductive. Many an open mind reveals only a vacuum! We should look for truth. Since we exist, we know that reality exists, and we should try to find the truth about it. I would like to suggest that science be approached from the

methodological perspective. This is a good place to begin. It may not be the best place to end, but there is something to be said for letting nature speak for itself. We are all entitled to draw our own conclusions, but the scientific process (i.e., the study of nature) will be more valid if we start from a neutral methodological perspective. Science of itself can be best approached without the encumbrance of preconceived ideas. After the initial homework is completed and after those areas beyond the scientific purview have also been considered, one may want to draw some broader conclusions, but one should be aware of the bases which led to the conclusions drawn.

There is a problem from confusing definitions of science. But the three kinds of science mentioned above underscore a more serious problem. The problem is the confounding of scientific data and interpretations. The data from nature can be very impressive, and it is easy to let the validity of the data undeservedly enhance an interpretation. For instance, we are all impressed with the three billion bases of the genome of man that are found in each cell. These kinds of data are used to point out how wonderful either evolution or creation is. But the data of themselves may not warrant either conclusion, nor may they warrant calling an opposing view impossibly narrow. We may want to use the data of nature in formulating our world views, and indeed we should use it as part of the total picture of reality available to us. However, much more than is common practice, we need to differentiate between data and conclusions. Too often our statements that science demonstrates this, or proves that, do not really mean that at all. They mean that in our particular interpretation of science we can refer to these data to support our viewpoint. In scientific endeavors we should try to clearly distinguish between the data of nature and interpretations of those data. A methodological approach to science would favor this. We should let the data of nature speak for themselves, and not make them say more than they do. Our private views can be expressed, but they should be identified as such, and should not be confounded with the facts of nature.

Ariel A. Roth

ARTICLES

BIBLICAL EVIDENCE FOR THE UNIVERSALITY OF THE GENESIS FLOOD

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WHAT THIS ARTICLE IS ABOUT

The extent of the Genesis Flood has been vigorously debated by biblical scholars. For those who accept a recent creation week of six literal consecutive, twenty-four-days, a universal Flood is necessary to explain the existence of the geologic column. The thesis of this study is that only the traditional interpretation which posits a literal, universal, worldwide Genesis Flood does full justice to all the relevant biblical data. The author summarizes twenty-two lines of biblical evidence — including terminological, thematic, contextual, grammatical-syntactical, literary-structural, logical-conceptual, theological, canonical, and typological which support the universality of the Genesis Flood.

I. CONFLICTING SCHOOLS OF INTERPRETATION

One of the most controversial aspects of the Flood narrative concerns the extent of the Genesis Flood. Three major positions are taken: (1) the traditional, which asserts the universal, worldwide nature of the Deluge; (2) limited or local flood theories, which narrow the scope of the Flood story to a particular geographical location in Mesopotamia; and (3) non-literal (symbolic) interpretation, which suggests that the Flood story is a non-historical account written to teach theological truth.

Against this third position, the non-historical, we must note the evidences within the biblical account affirming the historical nature of the Flood. In the literary structure of the Flood story (see Shea 1979), the genealogical frame or envelope construction (Genesis 5:32 and 9:28-29) plus the secondary genealogies (Genesis 6:9-10 and 9:18-19) are

indicators that the account is intended to be factual history. The use of the genealogical term *tôl^{e}dôṯ* ("generations," "account") in the Flood story (6:9) as throughout Genesis (13 times, structuring the whole book), indicates that the author intended this story to be as historically veracious as the rest of Genesis (Doukhan 1978, p 167-220). Walter Kaiser analyzes the literary form of Genesis 1-11 and concludes that this whole section of Genesis must be taken as "historical narrative prose" (Kaiser 1970).

A number of references in the book of Job may allude to the then-relatively-recent Flood (Job 9:5-8; 12:14-15; 14:11-12; 22:15-17; 26:10-14; 28:9; 38:8-11; see Morris 1988, p 26-30). The historical occurrence of the Flood is part of the saving/judging acts of God, and its historicity is assumed and essential to the theological arguments of later biblical writers employing Flood typology (see Davidson 1981, p 326-327); more on this point later.

Thus according to the biblical writers, far from being a non-historical, symbolical, or mythical account written only to teach theological truths, the Flood narrative is intended to accurately record a real, literal, historical event.

For evangelical Christians who take seriously the biblical record and accept the historicity of the Flood account, the question still remains whether the event described is to be taken as a local, limited flood or a universal, worldwide cataclysm.

The limited flood theories rest primarily on scientific arguments that present seemingly difficult geological, biological, and anthropological problems for a universal flood. (See Boardman 1990, p 212-223; Custance 1979, p 28-58; Kidner 1967, p 93-95; Mitchell 1982/1993; Ramm 1954, p 232-249; Young 1977, p 171-210). Since the scientific argumentation is not the subject of this article, I can only suggest that these problems are not insurmountable, although much more study is needed. A number of studies provides a growing body of evidence for diluvial catastrophism as an alternative to conventional long-age geology (see Coffin & Brown 1983; Roth 1985, 1986a, 1988; Whitcomb 1988; Baumgardner 1994a,b).

The local flood theories further assert that the terminology describing the extent of the Flood should be interpreted in a relative and not absolute universal sense. The various seemingly universal terms are regarded as implying only a limited locality; they are seen to indicate universality within the writer's worldview but a limited scope in terms of our modern

world view. (See Boardman 1990, p 223-226; Custance 1979, p 15-27; Kidner 1967, p 93-95; Ramm 1954, p 241-242.) We will take up this issue in the next section of this article.

The traditional conservative understanding of the Flood narrative is that Genesis 6-9 describes a universal, worldwide Deluge. It should be noted that this is also the view of the majority of liberal-critical commentators on Genesis 6-9, although they regard the biblical view as borrowed from the ANE accounts and not historical. (See Hasel 1975, p 78 and Note 16 for bibliography of representatives of this position: Fohrer, Koehler, Noth, Procksch, Skinner, Sarna, Speiser, von Rad, Vriezen, Zimmerli, etc. Some of these and other more recent representatives of this view are cited later in this article.)

The thesis of this article is that only the traditional position of a literal, universal worldwide Flood does full justice to the biblical data, and this universal interpretation is crucial for Flood theology in Genesis and for the theological implications drawn by later biblical writers.

II. BIBLICAL TERMINOLOGY IN GENESIS 6-9 INDICATING UNIVERSALITY

Perhaps the most important kind of biblical evidence for a universal Flood is the specific all-inclusive terminology found within the Genesis account itself. The late Gerhard Hasel has provided a careful treatment of this terminology in three penetrating studies in previous issues of *Origins* (Hasel 1974, 1975, 1978), and therefore I need not go into detail in this article. Eight different terms or phrases in Genesis 6-9, most echoing their counterparts in the worldwide creation account of Genesis 1-2, indicate universality.

First, the term *hā-āreṣ* "the earth," occurring 46 times in the Flood narrative (Genesis 6:12, 13, 17, etc.), always without any accompanying genitive of limitation, clearly parallels the usage of the same term in the account of worldwide, universal creation in Genesis 1:1, 2, 10. (While the term at times elsewhere may be used without a genitive and still in context be limited in scope to a certain "land," the explicit link to creation in the Flood account (see especially Genesis 6:6, 7) clearly gives a universal context for its usage in Genesis 6-9.)

Some have argued that if Moses had wished to indicate the entire world, he would have used the Hebrew term *tēbēl*, which means the world as a whole, or dry land in the sense of continents. This word is

never used in the Flood narrative. But it should be pointed out that *tēb̲ēl* is never used in the entire Pentateuch, including the creation account. In fact, the term appears no where in the narrative portions of the Hebrew Bible, but only in poetic texts (39 times) usually as a poetic synonym in parallel with *hā²āreṣ* "the earth." Thus this argument from silence does not adequately consider the contextual and poetic use of terminology, and carries little weight.

A second expression, "upon the face of all the earth" *ʿal-pᵉnê kol-hā²āreṣ* (Genesis 7:3; 8:9), clearly alludes to the first occurrence of the same phrase in the universal context of creation (Genesis 1:29; cf. Genesis 1:2 for a related universal expression), and thus here also implies a universality of the same dimension, i.e., the entire surface of the global mass. While the shortened term "all the earth" (*kol-hā²āreṣ*) by itself may have a limited meaning elsewhere when indicated by the immediate context (see Exodus 10:5, 15; Numbers 22:5, 11; 1 Kings 4:34; 10:24; 2 Chronicles 36:23; Genesis 41:57), the immediate context of the Flood story is the universal sinfulness of humankind whom God had made and created (Genesis 6:6,7) to have dominion over "all the earth" (Genesis 1:26), and the succeeding context is the universal dispersal of man after the Tower of Babel "upon the face of all the earth" (Genesis 11:4, 8, 9). In each of the four occurrences of the phrase "upon the face of all the earth" in Genesis outside the Flood story (Genesis 1:29; 11:4, 8, 9), it clearly has the universal sense of the entire land surface of the globe, and there is nothing in the Flood narrative to indicate any less universality. (It should be also noted that the one place in Genesis where in context a similar phrase "upon all the face of the earth" is not universal [the famine mentioned in Genesis 41:56], the Hebrew has a change in word order from elsewhere in Genesis [*ʿal-kol pᵉnê hā²āreṣ*]).

Third, the phrase "face of the ground" *pᵉnê hā²ad̲āmāh* (five times in the Flood narrative, 7:4, 22, 23; 8:8, 13), occurs in parallel with universal terms we have just noted, "the earth" (7:23) and "face of all the earth" (8:9); and this phrase "face of the ground" likewise harks back to its first usage in the universal context of creation (Genesis 2:6).

Fourth, the term *kol-bāśār* "all flesh" occurs 12 times in Genesis 6-9 (Genesis 6:12, 13, 17, 19; 7:16, 21; 8:17; 9:11, 15, 16, 17). The word *kol* "all" (which can occasionally express less than totality if the context demands), before an indeterminate noun with no article or possessive suffix, as here in Genesis 6-9, indicates totality. God's announcement to destroy "all flesh" (Genesis 6:13, 17) and the narrator's comment that

"all flesh" died (Genesis 7:21-22), except the inhabitants of the ark, indicates universal destruction. The one occurrence of *kol* plus the determinate noun *hābāśār* "all the flesh" (in Genesis 7:15) likewise indicates totality as well as unity.

Fifth, the expression "every living thing" (*kol-hāḥay*) of all flesh (Genesis 6:19), is another expression of totality; in 7:4, 23, the similar term *kol-hay^{e}qûm* means literally, "all existence." This term is given further universal dimensions by the addition of the clause harking back to creation — "all existence that *I have made*" (7:4) — and by the exclusive statement "Only Noah and those who were with him in the ark remained alive" (7:23). As Hasel puts it:

> *There is hardly any stronger way in Hebrew to emphasize total destruction of 'all existence' of human and animal life on earth than the way it has been expressed. The writer of the Genesis Flood story employed terminology, formulae, and syntactical structures of the type that could not be more emphatic and explicit in expressing his concept of a universal, world-wide flood* (Hasel 1975, p 86).

Sixth, the phrase "under the whole heaven" (*taḥaṯ kol-hāššāmāyim*, Genesis 7:19), is used six times in the OT outside of the Flood narrative, and always with a universal meaning (see Deuteronomy 2:25; 4:19; Job 28:24; 37:3; 41:11; Daniel 9:12). For example, the phrase is used to describe God's omniscience: "For He looks to the ends of the earth and sees under the whole heavens" (Job 28:24). Again, it depicts God's sovereignty: "Whatsoever is under the whole heaven is mine" (Job 41:11 KJV). (Note that the usage in Deuteronomy 2:25, describing "the nations under the whole heaven," is further qualified and limited by the phrase "who shall hear the report of you," and thus is potentially universal and not an exception to the universal sense.)

The universal phrase "under the whole heaven" or "under all the heavens" also universalizes the phrase "under heaven" (Genesis 6:17) in this same Flood context. The word "heaven" alone can have a local meaning [e.g., 1 Kings 18:45], but here the context is clearly universal. Ecclesiastes, which contains numerous allusions to creation, likewise utilizes the term "under heaven" with a universal intention (Ecclesiastes 1:13; 2:3; 3:1; cf. the parallel universal expression "under the sun" in Ecclesiastes 1:3, 9; 2:11, 17; etc.).

In the Flood account this phrase "under the whole heaven" is part of two forceful verses describing the extent of the Flood: "and the waters

prevailed so mightily upon the earth that all the high mountains under the whole heaven were covered. The waters prevailed fifteen cubits upward, and the mountains were covered" (7:19, 20). Critical scholar John Skinner notes that 7:19, 20 "not only asserts its [the flood's] universality, but so to speak proves it, by giving the exact height of the waters above the highest mountains" (Skinner 1930/1956, p 165).

The biblical language here simply cannot be explained in terms of a local sky, and certainly cannot refer to the local mountains being covered by snow, as some proponents of a local flood suggest. H.C. Leupold points out that the writer of vs. 19 is not content with a single use of *kol* ("all") in "all the high mountains," but "since 'all' is known to be used in a relative sense, the writer removes all possible ambiguity by adding the phrase 'under all the heavens.' A double 'all' (*kol*) cannot allow for so relative a sense. It almost constitutes a Hebrew superlative. So we believe that the text disposes of the question of the universality of the Flood" (Leupold 1942, p 301-302).

Seventh, Hasel devoted an entire scholarly article to the phrase "all the fountains [*maʿyenoth*] of the Great Deep [*tehôm rabbāh*]" (Genesis 7:11; 8:2), and showed how it is linked with the universal "Deep" (*tehôm*) or world-ocean in Genesis 1:2 (cf. Psalm 104:6: "Thou didst cover it [the earth] with deep [*tehôm*] as with a garment; the waters were standing above the mountains"). The "breaking up" and "bursting forth" (i.e., geological faulting) of not just one subterranean water spring in Mesopotamia, but of *all* the "fountains" of the Great Deep, coupled in the same verse with the opening of the windows of the heavens, far transcends a local scene. Hasel perceptively concludes that "the bursting forth of the waters from the fountains of the 'great deep' refers to the splitting open of springs of subterranean waters with such might and force that together with the torrential downpouring of waters stored in the atmospheric heavens a worldwide flood comes about" (Hasel 1974, p 71).

Eighth, in another article, Hasel (1978) shows how the Hebrew Bible reserved a special term *mabbûl* which in its 13 occurrences refers exclusively to the universal Genesis Flood (12 occurrences in Genesis, once in Psalm 29: 10). This word may be derived from the Hebrew root *ybl* "to flow, to stream." The term *mabbûl*, which in the Flood narrative is usually associated with *mayim* "waters," seems to have become "a technical term for waters flowing or streaming forth and as such

designates the flood (deluge) being caused by waters. ... *mabbûl* is in the Old Testament a term consistently employed for the flood (deluge) which was caused by torrential rains and the bursting forth of subterranean waters" (Hasel 1978, p 92-93). This technical term clearly sets the Genesis Deluge apart from all local floods, and is utilized in the Psalm 29:10 to illustrate Yahweh's universal sovereignty over the world at the time of the Noahic Flood: "The Lord sat enthroned at the Flood, and the Lord sits as King forever."

Summarizing regarding the technical terminology used for the extent of the Flood in Genesis 6-9, Hasel writes:

> *The Genesis flood narrative provides ample evidence of being an account which is to be understood as a historical narrative in prose style. It expects to be taken literally. There is a consistent and overwhelming amount of terminology and formulae ... which on the basis of context and syntax has uniformly indicated that the flood story wants to be understood in a universal sense: the waters destroyed all human and animal plus bird life on the entire land mass of the globe. To read it otherwise means to force a meaning on the carefully written and specific syntactical constructions of the original language which the text itself rejects* (Hasel 1975, p 87).

III. OTHER BIBLICAL EVIDENCE FOR A UNIVERSAL FLOOD

Many additional lines of biblical evidence converge in affirming the universal extent of the Flood and also reveal the theological significance of this conclusion. We will summarize fourteen points that emerge from the biblical text.

First, the trajectory of major themes in Genesis 1-11 — Creation, Fall, plan of redemption, spread of sin — is universal in scope and calls for a corresponding universal judgment. We have already noted in reference to specific Flood terminology the numerous allusions to the universal context of creation. The creation of "the heavens and the earth" certainly is not local in scope according to Genesis 1-2.

Likewise, the Fall of humanity in Adam and Eve led to the sinful condition of the entire human race (*hā-ḏām*), not just the inhabitants of Mesopotamia (see Genesis 6:5, 11; Romans 3:19; 5:12). Again, the Protoevangelium (first Gospel promise) outlined in Genesis 3:15, involves the universal moral struggle between the spiritual descendants (or "seed") of the serpent and the spiritual descendants ("seed") of the woman,

culminating in the victory of the representative Messianic Seed over the serpent (see Robertson 1980). This plan of redemption is certainly universal in scope.

In a similar way, the sinful condition of humankind described at the time of the Flood includes more than those living in the Fertile Crescent. From *God's* perspective, not simply from the culturally conditioned local view of the narrator, we have the results of the divine investigative judgment: "And God saw that the wickedness of man (*hā²dām*, humankind) was great in the earth, and that every imagination of the thoughts of his heart was only evil continually" (Genesis 6:5). Such universal sinfulness naturally calls for universal judgment.

Second, the divine purpose given for the bringing of the Flood makes explicit its universal scope: "And the Lord said, 'I will destroy man [(*hā²dām*), humanity] whom I have created from the face of the earth; both man, and beast, creeping things and birds of the air, for I am sorry that I have made them" (Genesis 6:7). Nothing less than a complete destruction of the human race (except for Noah, 6:8) seems envisaged. Given the length of time from creation (over 1650 years minimum), the longevity of the antediluvians (nearly a thousand years), and God's command at creation to "fill the earth" (Genesis 1:28), it is highly unlikely that the pre-Flood population would have stayed only in Mesopotamia. Thus the destruction of humanity would necessitate more than a local Flood.

Third, the genealogical lines from both Adam (Genesis 4:17-26; 5:1-31) and Noah (Genesis 10:1-32; 11:1-9) are exclusive in nature, indicating that as Adam was father of all pre-Flood humanity, so Noah was father of all post-Flood humanity. From the descendants of Noah "the nations spread abroad on the earth after the flood" (Genesis 10: 32), and the Tower of Babel experience spreads humanity across the globe (Genesis 11:1-19).

Striking extra-biblical evidence that all human races, and not just the nations of the Fertile Crescent, are included in the descendants of Noah, and retain memory of the universal Flood, is found in the amazing prevalence of ancient flood stories throughout the world. Over 230 different flood stories are known and occur among the most diverse peoples of the earth (see Frazer 1918, 1:105-361; Nelson 1931). A worldwide flood is by far the most frequently-given cause for past universally destructive calamities in the folk literature of antiquity (Thompson 1955, 1:182-194).

A remarkable number of these oral and written traditions agree upon the basic points of the biblical account: all humankind was destroyed by a great flood as a result of divine judgment against human sin, and a single man and his family or a few friends survived the deluge in a ship or other sea-faring vessel. The stories nearest to the area of the Dispersion at Babel are the closest in detail to the biblical account (see Heidel 1946, Jacobsen 1981, and Lambert & Millard 1969). This vast body of ancient witnesses to a worldwide Deluge is powerful testimony to the historicity and universality of the biblical Flood.

Fourth, the same inclusive divine blessing to be fruitful and multiply and fill the earth is given to both Adam and Noah (Genesis 1:28; 9:1). This is another linkage between universal creation and the flood, between the original beginning and the "new beginning." As the human race at creation flows from Adam and Eve, so the postdiluvial humanity is populated through Noah.

Fifth, the covenant (Genesis 9:9-10) with its rainbow sign (Genesis 9:12-17) is clearly linked to the extent of the Flood, and includes the whole earth (Genesis 9:13-17). If there was only a local flood, then the covenant would be only a limited covenant, and the rainbow sign of "the all-embracing universality of the Divine mercy" (Delitzsch 1888/1976, 1:289-290) would be stripped of its meaning.

Sixth, the viability of God's promise (Genesis 9:15; cf. Isaiah 54:9) and the integrity of God in keeping His promise is wrapped up in the worldwide extent of the Flood. This point cannot be underscored too heavily: if Genesis 6-9 describes only a local flood, then God has broken His promise every time another local flood has happened! The only way God's promise not to send another flood to destroy every living thing (Genesis 8:21) can be seen to have been kept is if the Flood was a universal one and the whole human race outside the ark was destroyed.

Seventh, the universality of the Flood is underscored by the enormous size of the ark detailed in Genesis 6:14-15 and the stated necessity for saving all the kinds of animals and plants in the ark (Genesis 6:16-21; 7:2-3). A massive ark filled with representatives of all non-aquatic animal/plant kinds would be unnecessary if this were only a local flood, for these kinds could have been preserved elsewhere in the world. Yet the divine insistence in the biblical record is that the animals were brought into the ark to preserve representatives of all of the various kinds (Genesis 6:19-20).

As a matter of fact, if only a local flood were in view, the building of any ark at all, even for Noah and his family, would have been superfluous — God could simply have warned Noah and his family in time to escape from the coming judgment, just as he did with Lot in Sodom. But the point of the narrative concerning the ark is that there was no other escape; in the midst of the Flood "only Noah and those who were with him in the ark remained" (Genesis 7:23).

Eighth, the covering of "all the high mountains" by at least 15 cubits (Genesis 7:19-20) could not involve simply a local flood, since water seeks its own level across the surface of the globe. Even one high mountain covered in a local Mesopotamian setting would require that same height of water everywhere on the planet's surface.

In this connection we note that it is not necessary to postulate the existence of mountains as high as Mt. Everest at the time of the Flood, and thus to require waters covering the earth to a depth of six miles, as some proponents of a local flood suggest would be necessary (see Ramm 1954, p 242). The antediluvian mountains were very possibly much lower than at present. Passages in the book of Job and Psalms may well be referring to the process of postdiluvian mountain uplift (see Job 9:5; 28:9; and Psalm 104:7-8).

Also in this connection we may address the objection that proponents of a local flood often raise, namely, that a worldwide Flood would imply "that the earth's surface was completely renovated during the flood year" and thus "prediluvian topography would have been exceedingly different from postdiluvian topography." This implication, they claim, is in conflict with biblical evidence which "strongly suggests that prediluvian geography did basically resemble postdiluvian geography" (Young 1977, p 210). Reference is made particularly to the topographical descriptions in connection with the Garden of Eden: the lands of Havilah and Cush, and the four rivers, two of which (the Tigris and the Euphrates) were familiar to the readers of Genesis in Moses' time.

What is not recognized in these arguments, however, is that although there are some similarities between the prediluvian and postdiluvian topography, there are more differences than similarities. Two of the rivers mentioned apparently no longer existed in Moses' time: the Pishon and Gihon are mentioned in terms of where they used to flow, in the postdiluvian areas of Havilah and Cush respectively. The other two rivers — the Tigris and Euphrates — are described as coming from a common source in the Garden of Eden, certainly far different from

their present courses. Thus the topographical descriptions in the early chapters of Genesis are in harmony with a worldwide Flood. Also, it is likely that survivors of the Flood would use familiar names for topographical features after the Flood, even though the earth's surface looked entirely different.

Ninth, the duration of the Flood makes sense only with a universal flood. The Deluge of rain from above and water from the fountains of the deep below continued 40 days (Genesis 7:17), and all the highest mountains were still covered five months after the Flood began; the tops of the mountains were not seen until after seven months, and the Flood waters were not dried up enough for Noah to leave the ark until one year and ten days had passed (see Genesis 7:11; 8:14). Such lengths of time seem commensurate only with a universal and not a local flood.

Tenth, the receding activity of the water (Genesis 8:3a, 54a) is described by Hebrew phrases which, in parallel with similar phraseology and grammatical construction for the "to and fro" motion of the raven (Genesis 8:7), should be translated as "going and retreating," (see Austin 1990, p 218; Hasel 1978, p 93) and imply oscillatory water motion lasting for 74 days (see Genesis 8:3-5). The waters rushing back and forth like in ocean tidal movement as the overall level gradually decreased, supports a universal interpretation such as "the oceanic energy impulse model of the flood" (Austin 1990, p 218), but is incongruous with a local flood theory.

Eleventh, the NT passages concerning the Flood all employ universal language: "swept them **all** away" (Matthew 24:39); "destroyed them **all**," (Luke 17:27); "he did not spare the ancient **world**, but preserved Noah with seven other persons, ... when he brought a flood upon the **world** of the ungodly" (2 Peter 2:5); "a few, that is eight persons, were saved through water" (1 Peter 3:20); Noah "condemned the **world**" (Hebrews 11:7). A local flood would not have ended the antediluvian world. As Archer states, "we have the unequivocal corroboration of the New Testament that the destruction of the human race at the time of the flood was total and universal" (Archer 1985, p 208).

Twelfth, the NT Flood typology assumes and *depends upon* not only the historicity, but also the universality, of the Flood to theologically argue for an imminent worldwide judgment by fire (2 Peter 3:6-7). Peter argues that just as there was a worldwide judgment by water causing the unbelieving antediluvian world to perish, so in the antitype there

must-needs-be a universal end-time judgment by fire bringing about the destruction of the ungodly (see Davidson 1981, p 326-327).

Thirteenth, key terms and motifs that we have already noted in Genesis 6-9 converge to make a major theological statement: the Noahic Flood is nothing less than the cosmic undoing or reversal of creation. Numerous biblical scholars have recognized this highly significant theological point of the Flood narrative. Nahum Sarna writes that "The Flood is a cosmic catastrophe that is actually the undoing of creation." In other words, creation is being undone, and the world returned to chaos (Sarna 1989, p 48).

Tikva Frymer-Kensky describes the Flood as "the original, cosmic undoing of creation" (Frymer-Kensky 1983, p 410; cf. Frymer-Kensky 1985, p 312). Claus Westermann speaks of the "invasion of chaos into the created order; the flood assumed cosmic proportions" (Westermann 1974/1984, p 434). Umberto Cassuto points out that at the high point of the Flood, "We see water everywhere, as though the world had reverted to its primeval state at the dawn of Creation, when the waters of the Deep submerged everything" (Cassuto 1964, p 97). David Clines uses the apt term *bouleversemen*t or "reversal" of creation to depict the theological significance of the Flood (Clines 1972, p 136). For Joseph Blenkinsopp,

> *... the deluge is an act of uncreation, undoing the work of separation by returning everything to the primeval, watery chaos from which the created order first arose* (Blenkinsopp 1992, p 83; cf. Blenkinsopp 1971, p 46-47).

Gerhard von Rad vividly underscores the universal implications of this undoing or reversal of creation:

> *... we must understand the Flood, therefore, as a catastrophe involving the entire cosmos. When the heavenly ocean breaks forth upon the earth below, and the primeval sea beneath the earth, which is restrained by God, now freed from its bonds, gushes up through yawning chasms onto the earth, then there is a destruction of the entire cosmic system according to biblical cosmology. The two halves of the chaotic primeval sea, separated — the one up, the other below — by God's creative government (ch. 1:7-9), are again united; creation begins to sink into chaos. Here the catastrophe, therefore, concerns not only men and beasts ... but the earth (chs. 6.13; 9.1) — indeed, the entire cosmos* (von Rad 1972, p 128).

Only a cosmic/universal Flood can theologically encompass the cosmic/universal reversal or undoing of creation described in Genesis 6-9.

Fourteenth and last, the cosmic reversal of creation is followed by a cosmic New Beginning. As Clines states it:

> *... the 'uncreation' which God has worked with the Flood is not final; creation has not been permanently undone. Old unities of the natural world are restored (8:22), and the old ordinances of creation are renewed (9:1-7)* (Clines 1972-73, p 138).

Jacques Doukhan has shown the precise literary parallels between the successive stages of "re-creation" in the aftermath of the Flood (Genesis 8-9) and the seven days of creation in Genesis 1-2 (Doukhan 1987, p 133-134; cf. Gage 1984, p 10-20):

1. The wind over the earth and waters. Gen. 8:1; cf. Gen. 1:2.
2. Division of waters. Gen. 8:1-5; cf. Gen. 1:6-8.
3. Appearance of plants. Gen. 8:6-12; cf. Gen. 1:9-13.
4. Appearance of light. Gen. 8:13-14; cf. Gen. 1:14-19.
5. Deliverance of animals. Gen. 8:15-17; cf. Gen. 1:20-23.
6. Animals together with men, blessing, food for men, image of God. Gen. 8:18-9:7; cf. Gen. 1:24-31.
7. Sign of covenant. Gen. 9:8-17; cf. Gen. 2:1-3.

Thus in the over-arching literary structure of the "re-creation" in the Flood narrative, the universal dimension of the Flood is underscored by detailed parallels with the cosmic creation account of Genesis 1-2.

IV. CONCLUSION

In conclusion, the question of the extent of the Genesis Flood is not just a matter of idle curiosity with little at stake for Christian faith. For those who see the days of creation in Genesis 1 as six, literal 24-hour days (see Hasel 1994), a universal Flood is an absolute necessity to explain the existence of the geologic column. A literal creation week is inextricably linked with a worldwide flood.

But a universal Flood is crucial not only in seeking to reconcile science and Scripture. It is also pivotal in understanding and remaining faithful to the theology of Genesis 1-11 and the rest of Scripture. (For a more detailed discussion of the theology of the Genesis Flood in its canonical context, see Davidson in press.) The many links with the

universal creation in Genesis 1-2 which we have noted in this study not only support the aspect of universality in the Flood, but serve to theologically connect Protology (Creation) and Eschatology (Judgment/Salvation) in the opening chapters of Scripture. The Flood is an eschatological step-by-step "uncreation" of the world and humanity followed by a step-by-step "re-creation" of the new world. "Thus," writes von Rad, "the story of the Flood — and this is theologically the most important fact — shows an eschatological world judgment.... The world judgment of the Flood hangs like an iron curtain between this world age and that of the first splendor of creation" (von Rad 1972, p 129-130).

The theology of the universal Flood is therefore the pivot of a connected but multi-faceted universal theme running through Genesis 1-11 and constituting an over-arching pattern for the entire subsequent worldwide *creation* revealing the character of the Creator and His original purpose for creation; humankind's turning from the Creator and the universal spread of sin ending in the universal "*uncreation*" through eschatological judgment; and *re-creation*, in the eschatological salvation of the faithful covenant remnant and the universal renewal of the earth.

REFERENCES

Anderson BW. 1978. From analysis to synthesis: the interpretation of Genesis 1-11. Journal of Biblical Literature 97(1):23-39.

Archer GL, Jr. 1985. A survey of Old Testament introduction. Rev. ed. Chicago: Moody Press.

Austin SA. 1990. Did Noah's Flood cover the entire world? Yes. In: Youngblood RF, editor. The Genesis debate: persistent questions about Creation and the Flood. Grand Rapids, MI: Baker Book House, p 210-228.

Bailey LR. 1989. Noah: the person and the story in history and tradition. Columbia: University of South Carolina Press.

Baumgardner JR. 1994a. Computer modeling of the large-scale tectonics associated with the Genesis Flood. Proceedings of the Third International Conference on Creationism. Pittsburgh: Creation Science Fellowship, p 49-62.

Baumgardner JR. 1994b. Runaway subduction as the driving mechanism. for the Genesis Flood. Proceedings of the Third International Conference on Creationism. Pittsburgh: Creation Science Fellowship, p 63-75.

Blenkinsopp J. 1971. Uncreation: the great flood: Gen 6:5-9:17. In: Bright L, editor. Pentateuch. Chicago: ACTA Foundation.

Blenkinsopp J. 1992. The Pentateuch: an introduction to the first five books of the Bible. NY: Doubleday.

Boardman DC. 1990. Did Noah's Flood cover the entire world? No. In: Youngblood RF, editor. The Genesis debate: persistent questions about Creation and the Flood. Grand Rapids, MI: Baker Book House, p 210-229.

Cassuto U. 1961. The documentary hypothesis and the composition of the Pentateuch. Abrahams I, translator. Jerusalem: Magnes Press.

Cassuto U. 1964. A commentary on the Book of Genesis, Vol 2. Abrahams I, translator. Jerusalem: Magnes Press.

Clines DJA. 1972-1973. Noah's Flood. Part I: The theology of the Flood narrative. Faith and Thought 100(2):128-142.

Clines DJA. 1976. Theme in Genesis 1-11. Catholic Biblical Quarterly 38:483-507.

Coffin HG, Brown RH. 1983. Origin by design. Washington DC: Review and Herald Publishing Association.

Custance AC. 1979. The Flood: local or global? The Doorway Papers, Vol. 9. Grand Rapids, MI: Zondervan Publishing House.

Davidson RM. 1981. Typology in Scripture: a study of hermeneutical tupoV structures (Andrews University Seminary Doctoral Dissertation Series, Vol. 2). Berrien Springs, MI: Andrews University Press.

Davidson RM. In press. The Flood. In: Evangelical Dictionary of Biblical Theology. Grand Rapids, MI: Baker Books.

Delitzsch F. 1888/1976. Genesis. In: Keil CF, Delitzsch F, editors. Biblical commentary on the Old Testament: the Pentateuch, Vol. 1. Martin J, translator. Grand Rapids: Wm. B. Eerdmans Publishing Co., p 33-414. Original work published 1888.

Doukhan JB. 1978. The Genesis creation story: its literary structure (Andrews University Seminary Doctoral Dissertation Series, Vol. 5). Berrien Springs, MI: Andrews University Press.

Doukhan JB. 1987. Daniel: the vision of the end. Berrien Springs, MI: Andrews University Press.

Filby FA. 1970. The Flood reconsidered: a review of the evidences of geology, archaeology, ancient literature and the Bible (with a foreword by Stephen S. Short). London: Pickering & Inglis Lts.

Fishbane M. 1971. Jeremiah IV 23-26 and Job III 13-13: a recovered use of the creation pattern. Vetus Testamentum 21:151-167.

Frazer JG. 1918. Folk-lore in the Old Testament: studies in comparative religion, Vol. 1. London: MacMillan.

Frymer-Kensky T. 1983. Pollution, purification, and purgation in biblical Israel. In: Meyers CL, O'Connor M, editors. The Word of the Lord shall go forth: essays in honor of David Noel Freedman in celebration of his sixtieth birthday. Winona Lake: Eisenbrauns, p 399-414.

Frymer-Kensky TS. 1985. The Flood. In: Achtemeier PJ, editor. Harper's Bible dictionary. San Francisco: Harper & Row, p 312-314.

Gage WA. 1984. The gospel of Genesis: studies in protology and eschatology. Winona Lake: Carpenter Books.

Hasel GF. 1974. The fountains of the great deep. Origins 1:67-72.

Hasel GF. 1975. The biblical view of the extent of the Flood. Origins 2:77-95.

Hasel GF. 1978. Some issues regarding the nature and universality of the Genesis Flood narrative. Origins 5:83-98.

Hasel GF. 1980. Understanding the living Word of God. Mountain View, CA: Pacific Press Publishing Association.

Hasel GF. 1994. The "days" of creation in Genesis 1: literal "days" or figurative "periods/ epochs" of time? Origins 21(1):5-38.

Heidel A. 1946. The Gilgamesh Epic and Old Testament parallels. Chicago: University of Chicago Press.

Jacobsen T. 1981. The Eridu Genesis. Journal of Biblical Literature 100:513-529.

Kaiser WC, Jr. 1970. The literary form of Genesis 1-11. In: Payne JB, editor. New Perspectives on the Old Testament. Waco, TX: Word, p 48-65.

Kidner D. 1967. Genesis: an introduction and commentary. The Tyndale Old Testament Commentaries. Wiseman DJ, editor. Downers Grove: Inter-Varsity Press.

Lambert WG, Millard AR. 1969. Atrahasis: the Babylonian story of the Flood. Oxford nd NY: Oxford University Press.

Leupold HC. 1942. Exposition of Genesis. Grand Rapids, MI: Baker Book House.

Lewis JP. 1968. A study of the interpretation of Noah and the Flood in Jewish and Christian literature. Leiden: E. J. Brill.

Mitchell TC. 1982/1993. Flood. In: The new Bible dictionary. 2d ed. London/Downers Grove: Inter-Varsity Press/InterVarsity Press, p 380-383.

Morris HM. 1988. The remarkable record of Job: the ancient wisdom, scientific accuracy, and life-changing message of an amazing book. Grand Rapids, MI: Baker Book House.

Nelson BC. 1931. The Deluge story in stone: a history of the Flood theory of geology. Minneapolis: Augsburg Publishing House.

Ramm B. 1954. The Christian view of science and Scripture. Grand Rapids, MI: William B. Eerdmans Publishing Co.

Robertson OP. 1980. The Christ of the covenants. Grand Rapids, MI: Baker Book House.

Roth AA. 1985. Are millions of years required to produce biogenic sediments in the deep ocean? Origins 12:48-56.

Roth AA. 1986a. Catastrophism — is it Scientific? Ministry (July) 59:24-26.

Roth AA. 1986b. Some questions about geochronology. Origins 13:64-85.

Roth AA. 1988. Those gaps in the sedimentary layers. Origins 15:75-85.

Sailhamer JH. 1990. Genesis. In: Gaebelein FE, editor. The expositor's Bible commentary, Vol. 2. Grand Rapids, MI: Zondervan Publishing House, p 1-284.

Sarna NM. 1989. The JPS Torah commentary: Genesis. Philadelphia, NY, Jerusalem: The Jewish Publication Society.

Shea WH. 1979. The structure of the Genesis Flood narrative and its implications. Origins 6:8-29.

Skinner J. 1930/1956. A critical and exegetical commentary on Genesis. The International Critical Commentary on the Holy Scriptures of the Old and New Testaments, Vol. 1. 2d ed. Edinburgh: T. & T. Clark.

Thompson S. 1955. Motif-index of folk-literature: a classification of narrative elements in folktales, ballads, myths, fables, medieval romances, exempla, fabiaux, jest-books, and local legends, Vol. 1. Bloomington: Indiana University Press.

von Rad G. 1972. Genesis: a commentary. Rev. ed. Philadelphia: The Westminster Press.

Wenham GJ. 1978. The coherence of the Flood narrative. Vetus Testamentum 28:336-348.

Wenham GJ. 1987. Genesis 1-15. Word Biblical Commentary, Vol. 1. Waco, TX: Word Books.

Westermann C. 1994. Genesis 1-11: a commentary. Scullion JJ, translator. Minneapolis: Augsburg Publishing House. Original work published 1974.

Whitcomb JC. 1988. The world that perished. Rev. ed. Grand Rapids, MI: Baker Book House.

Young DA. 1977. Creation and the Flood: an alternative to Flood geology and theistic evolution. Grand Rapids, MI: Baker Book House.

ANNOTATIONS FROM THE LITERATURE

ECOLOGY

Naeem S, Thompson LJ, Lawler SP, Lawton JH, Woodfin RM. 1994. Declining biodiversity can alter the performance of ecosystems. Nature 368:734-737.

Summary: The relationship of biomass to species diversity was investigated in this study. Three types of artificial communities were maintained under controlled conditions for at least 200 days. The number of trophic levels was the same in each community, but the total number of species varied. The less-diverse communities were subsets of the more diverse communities. Productivity was determined from measurements of community respiration, carbon fixation by photosynthesis, and plant size. The higher diversity community had, on average, greater productivity.

Comment: This result may have implications for the pre-flood biomass problem. It appears from the fossil record that the pre-flood world had much greater diversity than the present world. If productivity increases with diversity, as suggested by this experiment, the pre-flood world may have had much greater productivity than the present world.

GENETICS

Zhu N, Liggitt D, Liu Y, Debs R. 1994. Systemic gene expression after intravenous DNA delivery into adult mice. Science 261:209-211.

Summary: Under the right conditions, genes can be transferred into mice by intravenous injection. The injection includes an expression plasmid and a cationic liposome in a preferred ratio. Depending on the DNA dosage, the gene may be expressed in a few or many tissues, and over a period of time ranging from a few days to at least several months. This technique could facilitate gene therapy and other forms of genetic engineering.

Comment: Gene transfer has frequently been proposed as an agent of morphological change. Transfer of genes is generally thought to be

rare. If gene transfer is not so difficult as thought, its significance in morphological change is likely to be enhanced.

GENOME SEQUENCING STUDIES

Adams MD, Kerlavage AR, Fleischmann RD, Fuldner RA, Bult CJ, Lee NH, Kirkness EF, Weinstock KG, Gocayne JD, White O, + 74 other authors + Venter JC. 1995. Initial assessment of human gene diversity and expression patterns based upon 83 million nucleotides of cDNA sequence. Nature 377S:3-174 (p 3-17 = text; p 18-174 = Tables 2,6,9,10).

Summary: The structure and function of the human genome is of great interest to biologists, and much effort has recently been expended in an effort to sequence human DNA. This is a report of the results of sequencing some 83 million nucleotides, over 52 million of which are reported on here for the first time. Nearly 88,000 putative gene sequences were identified. Of these, 10,214 were previously known genes; the remainder had not been identified previously.

Comment: The total size of the human genome is about 3 billion base pairs, so the amount sequenced is still a rather small proportion of the total. Previous estimates of the number of human genes were on the order of 100,000 or 150,000 genes. The discovery of 88,000 likely gene sequences in such a small proportion of the genome suggests there may be many surprises remaining to be discovered.

Fleischmann RD, Adams MD, White O, Clayton RA, Kirkness EF, Kerlavage AR, Bult CJ, Tomb J-F, Dougherty BA, Merrick JM + 29 other authors + Venter JC. 1995. Whole-genome random sequencing of *Haemophilus influenzae* Rd. Science 269:496-512.

Summary: Is it possible for humans to understand how life operates? A critical step in doing so would be to have the complete DNA sequence for an organism. Now this has been accomplished. In this report, the entire DNA sequence is reported for the parasitic bacterium, *Haemophilus influenzae*. Since this species is parasitic, it probably does not represent the simplest possible living cell, but its genes might shed some light on the question of the simplest possible life form. The genome of *Haemophilus* has about 1.83 million base pairs, fairly typical for bacteria. A total of 1,743 coding genes were identified. A function could be assigned for 1007 of these genes. Another 347 genes matched

previously known DNA sequences for which the protein products are not known. The remaining 389 genes are newly discovered.

Comment: The ability to sequence DNA holds the promise that scientists will be able to identify the molecular mechanisms that maintain the living condition. Whether scientists will someday understand life remains to be seen, but it now appears, for the first time, that such knowledge may potentially be within our grasp. However, the large number of previously unknown genes show that our knowledge of even the simplest organisms is meager.

Fraser CM, Gocayne JD, White O, Adams MD, Clayton RA, Fleischmann RD, Bult CJ, Kerlavage AR, Sutton G, Kelley JM + 18 other authors + Venter JC. 1995. The minimal gene complement of *Mycoplasma genitalium*. Science 270:397-403.

Summary: This is the second organism to have its entire genome sequenced, *Mycoplasma genitalium* is thought to have the smallest genome for a self-replicating organism. Its genome is about 580,000 base pairs, and contains 470 predicted genes. Of the 470 genes identified, 318 represented known proteins and another 56 had been discovered in other organisms. The remaining 96 were previously unknown, and may represent genes unique to mycoplasmas. This species is missing several genes, but can survive because it is parasitic.

Comment: The genome sequence of this species may help in estimates of the minimum genome size needed for independent life. It seems likely that independent life is not possible with fewer than perhaps 250 or 300 genes. This estimate constrains explanations of the origin of life, making a naturalistic origin seem highly implausible. Another feature that may contribute to a better understanding of life is the possibility of identifying the number of gene families present, and comparing this with the numbers of gene families present in other types of organisms. New gene families require an explanation as to their origin, and it seems likely that a better understanding of the magnitude of this problem will show naturalistic processes to be implausible.

MOLECULAR PALEONTOLOGY

Cano RJ, Poinar HN, Pleniazek NJ, Acra A, Poinar GO. 1993. Amplification and sequencing of DNA from a 120-135-million-year-old weevil. Nature 363:536-538.

Summary: Recovery and sequencing of the gene for ribosomal RNA (rRNA) from a Cretaceous fossil weevil is reported here. The weevil was recovered from Lebanese amber thought to be Lower Cretaceous (Neocomian). The amber has been identified as coming from araucarian trees. The DNA sequence of the gene for the small ribosomal subunit (18S rRNA) was compared with sequences for several other insects, including an extant species from the same family (Nemonychidae). The two weevils differed by eight nucleotide positions (2.5%) in a 315 base-pair portion of the 5' region, and 34 positions plus 3 gaps (16.4%) in a 226 base-pair sequence from the internal transcribed spacer of the gene. The fossil weevil differs by 2.5% from the mealworm (*Tenebrio*), whereas the living weevil differs from the mealworm by 4.8%. The total difference for human and frog 18S rRNA genes is reported to be about 5%. These results are inconsistent with expectations of clock-like behavior of mutation rate in ribosomal RNA. They also provide another example of the discordance between molecular and morphological measures of similarity.

MOLECULAR PHYLOGENY

Litman GW, Rast JP, Shamblott MJ, Haire RN, Hulst M, Roess W, Litman RT, Hinds-frey KR, Zilch A, Amemiya CT. 1993. Phylogenetic diversification of immunoglobulin genes and the antibody repertoire. Molecular Biology and Evolution 10:60-72.

Summary: Typical vertebrate antibodies are made of two heavy chains and two light chains, containing V (variable), D (diversity), J (joining) and C (constant) regions. Each region is coded for by different DNA units (exons). Gene rearrangement in somatic cells is involved in producing the antibodies. Three patterns of arrangement are known for the heavy-chain gene. The most common gene arrangement is the "tetrapod-type," in which all the genes are arranged in a single sequence. The sequence consists of several hundred different V elements, 20-30 D elements, fewer than 10 J elements, and apparently a single C region with six exons. In somatic gene rearrangement, single V, D and

J regions are recombined with the C region to form a gene cluster for a specific antibody. Teleost fish apparently have a similar arrangement, although the numbers of elements vary.

Sharks have a different gene arrangement, with hundreds of separate gene clusters, each consisting of a V, two Ds, a J and a six-exon C region. Another unique feature of shark immunoglobulin genes is that about half the genes are joined in the germ line instead of somatically. A third unique feature is the absence of the regulatory octamer which is found associated with the B cell-specific immunoglobulin promoter in teleosts and tetrapods. The coelacanth has a pattern somewhat intermediate between the "tetrapod" and shark patterns. In the coelacanth, C and J regions are lacking, and V regions may be tandemly linked and may or may not be associated with a single D region.

Birds have a third pattern of gene arrangement. Here, "a single functional gene is the target for extensive gene conversion by flanking pseudogenes." Cyclostomes appear to lack immunoglobulin genes, having "humoral immunity" instead.

Comment: The diversity of immunoglobulin gene arrangements suggests separate design in their creation.

PALEONTOLOGY

Conway Morris S. 1993. Ediacaran-like fossils in Cambrian Burgess Shale-type faunas of North America. Palaeontology 36:593-635.

Summary: Frond-like fossils, possibly similar to sea-pens, have been discovered in the Burgess Shale of British Columbia and in Vermont. These fossils resemble Precambrian Ediacaran fossils, which have usually been found separated from Cambrian fossils. This unusual combination is interpreted as indicating that the Ediacaran fauna is not phylogenetically isolated from the Cambrian fossils.

Gingerich PD, Raza SM, Arif M, Anwar M, Zhou X. 1994. New whale from the Eocene of Pakistan and the origin of cetacean swimming. Nature 368:844-847.

Summary: Living whales are of two types: toothed whales and baleen whales. A third type, the archaeocetes, are found only as fossils. Two families of archaeocetes are known. A new genus of fossil archaeocete, named *Rodhocetus*, is described from Pakistan. The new fossil has characteristics suggesting it was fully able to swim as whales

do, while having some features resembling those of terrestrial mammals. Thus it is interpreted as being intermediate between land mammals and aquatic whales.

Comment: Archaeocetes are significantly different from living whales, and their relationship to living whales is somewhat uncertain. The stratigraphically lowest archaeocetes include both families and as many as eight genera, found in India, Pakistan, Egypt and Nigeria. The large taxonomic diversity and wide geographic range at first appearance seem inconsistent with the hypothesis of gradual origin by evolution. Attempts have been made to arrange archaeocete fossils in a morphological sequence from semiterrestrial to fully aquatic. The result is interesting, but the known genera are thought not to be a series of actual ancestors and descendants.

Thewissen JGM, Hussain ST, Arif M. 1994. Fossil evidence for the origin of aquatic locomotion in archaeocete whales. Science 263:210-212.

Summary: A new kind of fossil mammal has been discovered with a unique combination of features found in whales and in terrestrial mammals. The fossil was found in Eocene sediments in Pakistan. The authors propose that it should be classified as an archeocete whale, an extinct group of whale-like aquatic mammals. The fossil is named *Ambulocetus*, which means "walking whale." *Ambulocetus* had four limbs with large feet, and is thought to have had a long tail, features typical of terrestrial mammals. The proportionally large skull, the shape of the lumbar vertebrae, and the teeth are similar to other archaeocete whales. The authors infer an animal vaguely similar to a sea lion, which could walk awkwardly on land but was more at home in the water.

Comment: Conventional evolutionary theory proposes that living whales were derived from archaeocete whales, which were derived from a group of terrestrial mammals known as mesonychids. Mesonychids are found in Paleocene to Oligocene sediments; archaeocetes are apparently confined to Eocene sediments, and modern-type whales first appear in Eocene sediments. Living families first appear in Oligocene sediments.

The relationships of archaeocetes to living whales are not well understood. The near-simultaneous appearance in the geologic column of both archaeocete whales and toothed whales may indicate they have separate ancestries. The stratigraphically lowest archaeocete is *Pakicetus*, which is found below *Ambulocetus*. The "walking whale"

has been hailed as an evolutionary transition, but there are several important issues to be resolved before its status can be properly evaluated.

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.

MISBEHAVING FOSSILS

THE QUEST FOR LIFE IN AMBER. George and Roberta Poinar. 1994. Reading, MD: Addison-Wesley Publ. Co. 219 p. Hardcover, $25.00.

Reviewed by R.H. Brown, Yucaipa, California

When the behavior of a stubborn child fails to meet expectations, frustrated parents often plead, "Why don't you act your age?"

An increasing number of fossils do not "behave" in accord with expectations for their presumed age. These troublesome fossils contain DNA in concentrations that should be expected only in specimens less than 10,000 years old; yet they have been assigned ages that extend beyond 125 million years (Brown 1991, Wieland 1994).

George and Roberta Poinar have provided an up-to-date, comprehensive, and authoritative treatment of fossil DNA in amber (fossil pitch). In addition to covering the technical data, they outline the fascinating history of trade in amber, and narrate their world-wide search for amber in which ancient insects have been preserved. As they state in their preface:

> *This book is a chronological account of our adventures in the amber world, including travels to remote areas in search of amber, meetings with people along the way, and efforts to research and study organisms, cells, nuclei, and the oldest known DNA.*

In one episode the senior author ingenuously escaped confinement by a North African entrepreneur who evidently expected to obtain ransom money. The authors are good scientists as well as highly skilled writers. They have produced a book that, aside from its technical value, is exceptionally enjoyable to read. Many individuals will prize this book just for its 22 color micrographs of insect specimens in amber.

The list of organism types for which fossil specimens have been found in amber is amazingly long: algae, amoebae, ants, beetles, centipedes, dragonflies, feathers, fleas, flies, frogs, fruitflies, fungi, lacewings, land snails, leaflets, leaves, lizards, millipedes, mites, petals, pollen, protozoa, pseudoscorpions, rotifers, roundworms, seeds, spores, stoneflies, strepsiterones, walkingsticks, wasps, zoropterones. In addition to their reference to leaves in amber, the authors also review the data on DNA in fossil leaves from the Clarkia beds (putative age of 17-20 million years) in northern Idaho.

Since the publication of *The Quest for Life in Amber*, conclusive evidence has been obtained for the survival of not only DNA, but also of viable bacteria in amber presumed to be 25-40 million years old. The enzymatic, biochemical, and DNA characteristics of a bacterium from the gut of an amber-enclosed fossil bee has a close relationship with its modern equivalent (Cano and Borucki 1995).

On p 194 of Chapter 23, the authors state: "That ancient DNA exists at all is astonishing." However, DNA has been found in an amber-preserved weevil from Cretaceous (120-135 million-year conventional age) deposits in Lebanon. On the other hand, a biblical flood model for the geologic column is consistent with remnant DNA in at least some fossils from *all* Phanerozoic levels. The amount of DNA, and the degree of base-pair sequence preservation, in a specific specimen would depend on temperature, association with moisture and oxygen, and other factors that determine the rate of degradation.

In their preface the Poinars assert that "the discovery of nuclei and DNA in amber inclusions ... disproved earlier theories on the limited life span of [DNA]...." Another specialist, in comments on fossil DNA research (Goldberg 1994), made a significant statement of basic principle: "... establishing the validity of empirical results by determining how well they fit theoretical expectation, is at best arrogant, and at worst, regressive." Goldberg evidently was castigating individuals who challenged the claims for discovery of DNA greater than 17 million years old. The extreme unlikelihood of appropriate types of modern DNA penetrating the amber enclosure of a fossil insect, and the minor mutational differences between the fossil DNA and the corresponding modern equivalent, definitely exclude contamination as an appropriate explanation for DNA found in fossil specimens.

But, age estimates in the 17-225 million year range (see p 181 for 225 My) are theoretical. Whether correct or incorrect, they are based

on presumptions which are beyond direct experimental validation. The detection of DNA in fossils with such age assignments can call the age assignments into question. They can also be interpreted as "proof" for DNA survival ^{3}10,000 times longer than can be expected on the basis of observations of DNA degradation over the historical time range. The scientific community is so adamantly committed to a uniform process development of the Phanerozoic portion of the geologic column over ~600 million years, that it is blind to the implication of residual amino acids and DNA. This evidence suggests the existence of life on planet Earth for only a relatively short span of time more closely in agreement with the chronological specifications in the Bible.

REFERENCES

Brown, RH. 1991. Fresh bread; old fossils. Origins 18:89-92.

Cano, RJ, Borucki MK. 1995. Revival and identification of bacterial spores in 25- to 40-million-year-old Dominican amber. Science 268:1060-1064.

Goldberg, EH. 1994. Antediluvian DNA research. Nature 367:692.

Wieland, C. 1994. Ancient DNA and the young earth. Creation Ex Nihilo Technical Journal 8(1):7-9.

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 CANYON OF CANYONS

GRAND CANYON: MONUMENT TO CATASTROPHE. 1994. Steven A. Austin, editor. Santee, CA: Institute for Creation Research. 284 p. Paper, $19.95.

Reviewed by R.H. Brown, Yucaipa, California

As stated in the Preface, this book is intended to serve as a "field guide to the geology, biology, and human history of the world's greatest natural wonder," prepared from a "distinctly creationist viewpoint." The treatment is in nontechnical language at the undergraduate college level and provides an easy introduction to geological concepts and terminology. Scholarly documentation is provided for readers who wish to investigate technical details. The text is profusely illustrated with 120 excellent line drawings and 50 color photographs.

Suggestions concerning the origin of the various geologic and paleontological features associated with the Grand Canyon are discussed from both a long-geologic-age viewpoint and a recent-flood-geology viewpoint. At the present state of knowledge, neither of these viewpoints has produced a 100% successful explanation for all these features; but readers of this book may expect to be surprised and/or assured by the large proportion of features for which the biblical viewpoint provides a scientifically superior explanation.

The authors' model for development of the Canyon is based on mega-erosion and associated tectonic events, resulting from two episodes of catastrophic drainage of immense post-Flood lakes (inland seas). Suggestions are given for research that might elaborate and/or produce additional support for their model.

Chapter 6 gives a compilation of radioisotope-age data significant to an understanding of the formation of the Grand Canyon and provides

what may well be the best and most thorough treatment of radioisotope age with respect to the actual associated real-time significance.

The treatment of modern biology in the Canyon (Chapter 8) contains interesting data on plant and animal adaptation for desert survival, and gives impressive examples of evident design. This chapter can serve as a good introductory treatment on the presumed mechanics of evolution from simple to complex organisms.

The usefulness of the book is enhanced by the glossary in Appendix E. Appendix D provides a list of questions that may be useful for group study based on the book.

The high technical standard otherwise exemplified by this book is compromised by the assertion that "a fallen 90-foot fruit tree with ripe fruit and green leaves still on its branches has been found in frozen ground of the New Siberian Islands" (p 193). No reference is given by which the reader can check the authenticity of such an unusual find.

Grand Canyon: Monument to Catastrophe combines biblical interpretation with technical description and modeling. A reader who is mainly interested in the technical/scientific aspects may not appreciate all the accompanying biblical interpretations. For example: did God introduce "death and bloodshed into the world, that we could have a doorway through which we could walk in order to be saved" (p 3), or are death and bloodshed natural consequences of sin? Does the smaller variety of organisms today represent a purging of corruption (p 150), or is it a consequence of more limited capability of the post-Flood environments? The effectiveness of this book as a witness for biblical creationism would be enhanced without such theological overlays.

In promotion of the Canopy Theory, Chapter 9 moves from observation and good scientific analysis into speculation. Although widely advocated in creationist literature, this theory is based on questionable exegesis of Genesis 1:6-8, and is thoroughly contradicted by basic considerations of natural science.[1] To have the pre-Flood atmosphere contain 40 ft^3 of water per square foot of Earth surface would require either surface temperatures greater than 220°F (water as vapor), or an unsustainable cloud cover (water as droplets or ice crystals supported by upward air currents). Elsewhere the editor of this book has proposed a physically justifiable "fountains of the deep" (Genesis 7:11) model for the basic sources of sufficient water to inundate the Earth during the flood.[2]

With due recognition of the negative aspects noted above, I can unhesitatingly give this book the highest recommendation for the library of anyone interested in the geology of the Grand Canyon or in the validity of the record in Chapters 6-8 of Genesis.

ENDNOTES

1. Morton GR. 1979. Can the canopy hold water? Creation Research Society Quarterly 16:164-169.
2. Austin SA et al. 1994. Catastrophic plate tectonics: a global flood model of Earth history. Proceedings of the Third International Conference on Creationism. Pittsburgh: Creation-Science Fellowship, p 609-621.

GENERAL SCIENCE NOTES

FOSSIL REEFS AND TIME

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WHAT THIS ARTICLE IS ABOUT

Ancient fossil reefs found within Earth's sedimentary rocks are considered to be a challenge to the biblical concept of creation. Their presence is regarded as favoring models which propose that life developed gradually over many millions of years. The problem for the biblical model is that an abundance of time is required to grow a reef and the hundreds of fossil reefs found would require so much time to develop that they cannot be accommodated into the biblical time framework of a recent creation a few thousand years ago.

Do these fossil reefs really negate the biblical account of beginnings? There are alternative interpretations that do not require long ages. For instance, these "reefs" may not be real reefs. There are serious questions about the authenticity of many fossil reefs, because they differ significantly from present reefs. Another possibility is that some fossil reefs could have been formed between the time of creation and the flood described in the Bible, and were subsequently buried by that world-wide catastrophe. Both alternatives seem plausible.

INTRODUCTION

Pilots of ships spend considerable time worrying about rocky structures called reefs which lie at or just below the surface of the ocean. These reefs are especially common in warm tropical seas, where coral, algae and associated organisms slowly build these insidious structures which have caused many a ship to founder. Reefs, sometimes called coral reefs, come in many sizes and shapes and represent some of our most complex marine ecological systems.

Figure 1 illustrates a cross section of a typical reef. The reef core is the most important part. It is a hardened structure, built up by living organisms, that resists the pounding of the ocean's waves. On the ocean side of the reef core is the fore reef, which consists of layers of sediment

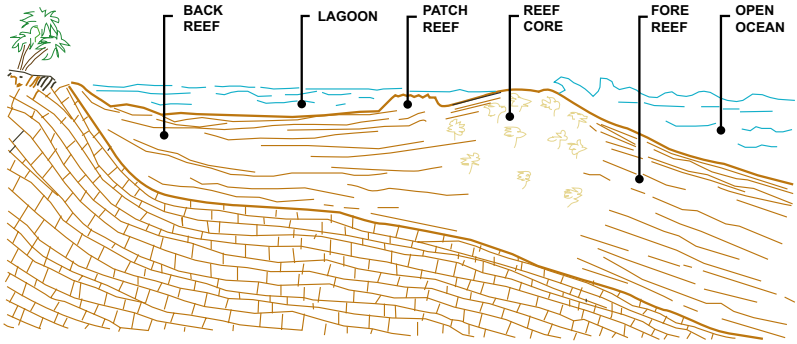


FIGURE 1. Cross-section through a typical reef. The most significant part is the reef core which is a hard wave-resistant structure built slowly by organisms. The core supplies some sediments to both the fore reef and the back reef.

dipping towards the deeper ocean. These sediments can: 1) originate from the reef core, 2) be produced by organisms living on the fore reef, or 3) be brought in by ocean currents. On the back side of the reef, the reef sediments underlie a shallow lagoon with calmer waters. The origin of the back reef sediments is comparable to that of the fore reef. Sediment can also be washed in from a land source or be precipitated by evaporation of the lagoonal sea water. Sometimes small reefs called patch reefs will form as an accessory to a large reef complex (Fig. 1). Reefs are built mostly of limestone (calcium carbonate).

While the general picture given above leaves little question as to what a modern reef is, the identification of a fossil reef is complicated by the fact that there are similar structures which are formed in a different way. Especially noteworthy are shallow-to-deep-water banks of sediment. These are formed mainly by the accumulation of sediments transported by water currents. They are sometimes associated with organisms such as eel grass that can facilitate the trapping and hardening of sediments. Such structures can resemble a modern reef formed by the slow growth of living organisms.

Fossil reefs are the remains of ancient reefs. These are usually found in the rocky sedimentary layers of Earth's crust. Occasionally, usually as a result of erosion, fossil reefs are exposed at Earth's surface, where they are much easier to study. The identification of fossil reefs is more difficult than that of present reefs. Problems include: 1) the absence of the ocean, 2) the complex structures of reefs, 3) differences in the

reef-forming organisms compared to modern reefs, and 4) changes that take place within the rocks over time. Because of economic reasons there has been considerable interest in these fossil reefs. Many of them serve as good traps for oil; and the scientific literature discussing them is voluminous. The general references by Braithwaite (1973), Dunham (1970, 1972), Heckel (1974), James (1983), James & Macintyre (1985), Rosen (1990), Scoffin (1987, p 77-88), Wilson (1975), and Wray (1971) are especially pertinent to the broad questions being considered in this note.

There are problems with fossil reefs. They center on questions of identification, structure, composition, and especially about how these ancient reefs were formed. The terminology used to describe these is complicated by the fact that various writers sometimes use the same terms in different ways. Some identification schemes are based on structure and others on how the reefs are thought to have formed, or both. Heckel (1974) notes that the terminology is particularly confusing "regarding terms that are strongly genetic in meaning"; i.e., those terms that deal with the mode of origin. For this and other reasons, a plethora of terms have been used to designate these ancient reefs, including: ecologic reef, stratigraphic reef, bioherm, carbonate buildup, allochthonous reef, autochthonous reef, true reef, reef mound, mud mound, bank, or knoll, etc. The term "reef" itself has almost become too general a term for use in a discussion of fossil reefs. It can specify any rock unit that seems to have been elevated above its surroundings.

THE TIME QUESTION

Fossil reefs are of special interest when the question of origins is being considered. The salient issue is the amount of time required to form these ancient structures. If an abundance of time was required for these reefs to form, they are a severe challenge to the biblical account of origins. The Bible describes the creation of life by God during a six-day creation event which took place a few thousand years ago. The Bible goes on to describe a world-wide flood which occurred well over a millennium later, and lasted about one year. In the biblical context, this flood accounts for most of the fossiliferous sedimentary layers of Earth's crust. If the sedimentary layers and their varied fossils were laid down over millions of years, as is commonly interpreted, they challenge both the creation and flood accounts given in the Bible. If fossil reefs found

in these layers formed at the slow rate at which we see present reefs forming (Roth 1979), at least scores of thousands of years would be required to produce the superimposed fossil reefs found in the fossil record. Is the biblical concept of a recent creation in error, or is the geologic interpretation of fossil reefs in error? Both concepts cannot be correct.

This discussion will focus on the rate of formation of these fossil reefs. Specifically, did they form as a result of a slow biological process by reef-producing organisms, as is noted for present living reefs, or do they represent rapid accumulations of sediments transported and deposited by the waters of the Genesis flood? In the context of this question it will be convenient for us to identify two main types of reefs (James 1983). *Allochthonous reefs* designates reefs considered to have been formed by the transport of sediment. Their formation can occur rapidly, but not necessarily so. In contrast *autochthonous reefs* designate reefs that have formed as a result of slow biological activity. These reefs can only form slowly. Allochthonous reefs can be accommodated into the biblical model of a recent creation. Only under special circumstances, which will be discussed later, can any autochthonous reefs be so accommodated.

THE FOSSIL REEF RECORD

Hundreds of fossil reefs are reported throughout much of the geologic column, starting from very low (Precambrian) sedimentary layers to the present (Heckel 1974; James 1983, p 387-425; James & Macintyre 1985, p 37-47; Wilson 1975). These reefs, with notable exceptions, tend to be different from present reefs (Ladd 1950; Hodges 1987). They are often much smaller; some only in the meter range, and they are usually produced by different kinds of organisms than those that build the present reefs.

The lowest (Precambrian) reefs in the geologic column are thought to be produced by the mechanical trapping of sediments and the chemical action of various kinds of microorganisms living on their surfaces. These structures represent a kind of laminated deposit called stromatolite. Various forms and combinations of stromatolites are reported as reefs.

Also located in the lower part of the geologic column (Cambrian) are reefs that are produced by sponge-like organisms called archaeocyathids. They differ from any presently known living organisms.

Higher up in the geologic column (Ordovician, Silurian, and Devonian), are some larger more significant reef-like structures with reported ecological developmental sequence and an organization into reef core and flank beds which dip away from the core (see Devaney et al. 1986 for discussion). Some reef descriptions include back reef lagoonal deposits. The most common organisms found in these reefs are sponges, including peculiar laminated stromatoporoids. Coral organisms that are different from modern corals are sometimes moderately abundant. Algae and bryozoa (moss animals) are less important. Some of the organisms in the reef cores appear to be in position of growth (e.g., Manten 1971, p 83, 435-438; Hodges & Roth 1986) while others do not (e.g., Heckel 1974, Wengard 1951). The orientation of the fossil in a reef is an important indicator of whether the reef formed by allochthonous or by autochthonous means. A position of growth suggests a slow autochthonous growth process, while unoriented fossils reflect an allochthonous transport process. Unfortunately the identification of what is in growth orientation has too often turned out to be quite subjective. Also, allochthonous blocks of reef material can contain fossils in apparent growth position.

In this same part of the geologic column we also find many mounds of fine lime (calcium carbonate) mud with few fossils (see Hodges 1987). Since coral reefs are composed of lime, these mounds are of considerable interest. Mud mounds could accumulate quite rapidly by an allochthonous transport of sediment.

A little higher up in the geologic column (Carboniferous) one also finds a number of large sedimentary mounds composed of fine lime sediment sometimes with crinoid fossil deposits flanking their steep sides. These enigmatic structures, which range from many meters to kilometers in size, are called Waulsortian mounds — so named after mounds located near the village of Waulsort in Belgium. Aggregations of such mounds have been interpreted as a large barrier reef complex which would be expected to be subjected to significant wave activity. But a question remains as to how much pounding by waves these fine- sediment structures could withstand.

Higher in the geologic column (Permian through Jurassic) small to huge structures interpreted as reefs have been described. The organisms that presumably formed them are again different from those forming modern reefs. In addition to sponges, there are relatively small amounts of algae, coral, bryozoa, and a problematic tube-like organism called tubiphytes.

Some bizarre, but now extinct, bivalve molluscs called rudists form reef-like structures near the upper part of the geologic column (Jurassic and Cretaceous). Coral is occasionally found among the rudists (e.g., Scott et al. 1990). Rudists (Fig. 2) are elongated, clam-like molluscs that have one shell somewhat similar in shape and size to an ordinary

FIGURE 2. Rudist fossils from a rudist reef in central Texas. Note the coin for scale. Many of the circular structures are cross sections of the elongated rudist mollusc shells. The elongated fossils represent tangential or longitudinal sections.

clam shell, while the other can be very long, sometimes up to 1.5 m in length.

In the upper part of the geologic column (Cenozoic), fossil reefs are not very abundant. The associated organisms are mainly coral and algae, similar to those forming modern living reefs.

CHANGING INTERPRETATIONS OF FOSSIL REEFS

Because fossil reefs and their past environment are difficult to identify, and because they are so varied in composition and structure, it is not surprising that interpretations of these challenging sedimentary structures are sometimes revised. Four examples follow.

FIGURE 3. View of part of the huge Permian (Capitan) Reef exposed in the Guadelupe Mountains of Texas and New Mexico. The massive white cliff at the top of the picture is interpreted as the reef core, while the bedded layers which dip to the right are interpreted as the fore reef.

The Permian Reef Complex

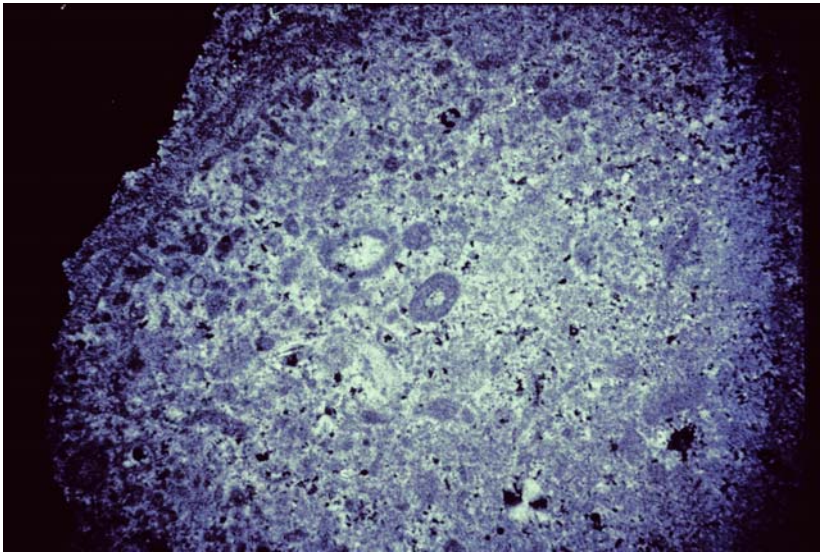
The huge Permian (Capitan) Reef is among the most, if not the most, studied fossil reefs. Located in the southwestern United States, this ring-shaped reef has a diameter of around 200 km, and a length of over 700 km. Most of the reef lies underground; however, about 40 km of it are well exposed in the Guadelupe Mountains of Texas and New Mexico. The upper portion of Figure 3 shows the lighter massive reef core. This core overlies the fore reef beds that dip downward to the right. In this reef configuration the ocean is considered to have been in the middle of the ring (right), while the back reef is around the outside (left). The world-famous Carlsbad Caverns is dissolved right out of the reef core of this reef.

Interpretations of this structure have had a long and varied history (Cys et al. 1977, Wood et al. 1994). In general, during the earlier part of this century the Permian Reef was considered to be a true autochthonous wave resistant barrier type of reef (e.g., Lloyd 1929, Hayes 1964, King 1948, Newell et al. 1953, and Newell 1955). However, as early as 1937, Lang began to question the barrier reef concept. During the past four

decades a host of authors have questioned the traditional reef interpretation, opting instead for some kind of deposit in deeper water (e.g., Achatier 1969; Cys et al. 1977; Dunham 1972; James & Macintyre 1985, p 40; Pray 1977; Babcock & Yurewicz 1989). However, recently Kirkland-George (1992) and Kirkland-George and others (1993) have revived the old barrier reef model on the basis of the location of some fossil algae that are considered to require a lagoonal environment. In order to have a lagoon there must be a barrier reef.

One of the main problems with the traditional reef interpretation of the Capitan Reef complex is the lack of reef frame builders. The massive reef core consists mainly of fine, calcium-carbonate mud (Fig. 4). The robust wave-resistant reef frame builders of our present reefs are missing. There are some sponges but sponges are not known to produce great reefs; and there is insufficient algae to bind the sediments. A number of the sponges are bottom side up, interpreted as growing downward from the top surface of cavities in the reef core (Wood et al. 1994). In order to have cavities, the reef structure would have to be formed first. Because of the abundance of fine sediments, many investigators have concluded that this is not a reef. It is considered to be an

FIGURE 4. Photomicrograph of sediments from the reef core of the Permian (Capitan) Reef. Note small circular and elongated fossil pieces. The photo is approximately 25 times normal size.



underwater mud bank formed by the accumulation of fine sediments in deeper and quieter waters. Some authors, such as Pray (1977) argue that the "reef" was always below the surface of the ocean. The mud bank interpretation fits better with an allochthonous interpretation than with an autochthonous one.

A second major problem with the reef concept is that higher sedimentary layers behind (back reef area) the reef core dip down towards the core and are associated with the core in a way which indicates that the core must have been below the surface of the ocean when it and the associated higher sedimentary layers were formed. Accordingly, the reef core was not a wave-resistant structure. Several lines of evidence indicate that this relationship is not merely due to tilting of sediments after deposition (Hurley 1989, Yurewicz 1977, Babcock & Yurewicz 1989).

The Steinplatte Reef

In the High Calcareous Alps of western Austria lies the famous Steinplatte Reef. This fossil (Triassic) reef forms a dramatic barren limestone cap that stands above the wooded hillsides. When viewed

FIGURE 5. View from the west of the Steinplatte Reef in western Austria. What is considered to be the fore reef is the whitish cliff above the wooded hillsides. It is partially hidden by the clouds. The reef core lies behind the visible fore reef.

from the west (Fig. 5), the main cliff of exposed limestone represents the fore reef. The reef core lies behind and on top of the cliff. The reef has been studied for over a century. Fossils are abundant, but do not present a convincing picture of a defined reef structure. There have been at least three major studies, each giving different locations for the main parts of the reef (Piller 1981). More recently a geologist restudied the Steinplatte Reef (Stanton 1988) and pointed out the lack of a biological skeletal framework necessary to build a wave-resistant reef. He characterized the so-called Steinplatte Reef as a "sandpile," and commented further that "The Steinplatte is not an ecologic reef nor is it easily considered a reef by any other definition." A sandpile could represent allochthonous deposition.

Nubrigyn Algal Reefs

The Nubrigyn Formation is found in the lower part of the geologic column (Devonian) that is exposed in eastern Australia. This formation has gained international prominence (Conaghan et al. 1976, Percival 1985) as a classic example of reefs formed by algae. Wolf (1965a,b,c,) reports on several hundred algal reefs from this region. His interpretation has been restudied (Conaghan et al. 1976, Mountjoy et al. 1972), and an entirely different interpretation has been proposed. These algal reefs do not represent autochthonous structures that grew where found. They represent part of a massive debris flow that carried blocks as large as 1 km across. Evidence for an allochthonous origin includes a variety of kinds and sizes of rocks mixed into a dark clay matrix, as would be expected from a massive debris flow, and evidence for breaking of the rocks in transport, as seen by their sharp edges (Fig. 6).

Muleshoe Mound

The Muleshoe Mound (Carboniferous) is illustrated in Figure 7. It is one of a number of similar structures found in southern New Mexico (Laudon & Bowsher 1941). Muleshoe Mound is about 100 m thick. It represents one of the many Waulsortian mounds formed of fine lime mud mentioned earlier. Various names such as bioherm, carbonate buildup, mound or reef (Heckel 1974) have been applied to these enigmatic structures. Bolton et al. (1982) and Wilson (1975, p 148-168) review some of the scientific literature written about these. These mounds are characterized by a core composed mainly (50-80%) of calcium carbonate mud. Some are spectacularly conical with relatively steep sides. In some

FIGURE 6. Debris flow of the Nubrigyn Formation of eastern Australia. Note the variety of kinds of rocks floating in a dark clay matrix as expected for a debris flow. Also note the broken edges on the whitish limestone block to the left indicating vigorous transport. The coin to the left gives the scale.

FIGURE 7. Muleshoe Mound, a Waulsortian lime deposit from the Sacramento Mountains in New Mexico.

mounds, the mud core gives evidence of bedded layers (Cotter 1965, Giles 1995) which can suggest transport of sediments. Pray (1965) has described the intrusion of dikes into these mounds coming from soft sediments below them. This indicates that the layers below were still soft when the intrusion took place. (See Hornbacher 1984 and Roth 1992 for related information.)

Early interpretations of these puzzling structures suggested some kind of autochthonous biological buildup, probably by crinoids, algae or bryozoa (Pray 1958; Wilson 1975, p 160-166), but the scarcity of such fossils is a problem. Some have suggested inorganic cementation (Pray 1969). The most accepted model probably is that these mounds were formed by the slow allochthonous accumulation of fine, water-transported sediments. This accumulation is often postulated to have taken place in deep water below the level of destructive waves. Location of the mound at the base of an underwater slope which could serve as a source of sediment is also favored (Heckel 1974; Wilson 1975, p 165). Giles (1995), in studying Muleshoe Mound, has proposed formation by "massive slope failure of rapidly accumulated sediments." Semi-coherent "glide blocks" representing the core which had slid downslope were then flanked by debris flows and turbidites. These flanking sedimentary layers could also be deposited rapidly.

EVALUATION OF FOSSIL REEFS

While most paleontologists accept the concept that fossil reefs are true reefs, there is ample room for doubt. Rosen (1990) states that "Various fossil structures have come to be called reefs simply because their features *seem* to include framework or relief, in the absence of clear evidence to the contrary." Lowenstam (1950, p 438) also expresses concern about lack of evidence when he states: "we find in many reef studies that, once we are past the definition, the evidence is too often so inadequate that the reader remains in doubt as to whether or not the author was dealing with true reefs." Others "have expressed frustration at using modern reefs to interpret their ancient counterparts" (Hubbard et al. 1990).

The identification of ancient stromatolites mentioned earlier has also been controversial. The sedimentologist Ginsburg (1991) points out that "Almost everything about stromatolites has been, and remains to varying degrees, controversial." Stromatolite specialist Hoffman (1973)

notes: "Something that haunts geologists working on ancient stromatolites is the thought that they might not be biogenic at all." If they are not biogenic, they would not necessarily be restricted to a slow autochthonous biological process. Questions have also been raised about the peculiar rudist reefs formed by the elongated molluscs referred to above. Gili et al. (1995) "dispute [the] ... assertion ... that rudist formations commonly developed as reefs." It is their opinion that "individual rudist congregations are volumetrically limited, relative to sediment. They are often loosely constructed, and they evidently showed little, if any, original relief" (see also Skelton et al. 1995). In the rudist reefs of central Texas, the organisms in the reef core, which would be expected in growth position are described in "random position"; while the organisms in the flank beds, which are more subject to transport and which might be expected to be more in random position, are reported in "growth position" (Robertson 1972). All of these factors raise questions about the authenticity of autochthonous rudist reefs.

As noted above, reinterpretations of fossil reefs are not uncommon. Some of the reinterpretations reflect the newer trend in geology towards catastrophic interpretations that allow for rapid geologic changes. This is in contrast to the older uniformitarian concept which emphasized slow gradual changes and probably favored an autochthonous interpretation of many ancient reef-like structures. Mountjoy et al. (1972) published information that reflects the trend towards catastrophism. They report on four ancient reef-like structures (including the Nubrigyn reef) that have been reinterpreted as debris flows. Debris flows form rapidly.

Probably the most important problem with fossil reefs is the usual absence of organisms that would form a wave-resistant framework for the reef. Without this framework, there is no guarantee that the reef took a long time to grow. The sedimentologists Blatt, Middleton & Murray (1980, p 447) comment on the problem:

> *Closer inspection of many of these ancient carbonate 'reefs' reveals that they are composed largely of carbonate mud with the larger skeletal particles 'floating' within the mud matrix. Conclusive evidence for a rigid organic framework does not exist in most of the ancient carbonate mounds. In this sense, they are remarkably different from modern coral-algal reefs.*

Skeletal particles floating in a mud matrix could result from relatively rapid transport as in a debris flow.

FOSSIL REEF TRANSPORT

There is little question that there are major problems with the identification of fossil reefs. However, can one be sure that there are no authentic autochthonous reefs anywhere in the fossil record? One single fossil reef that would normally have taken many years to grow could negate the biblical account of beginnings with its requirement that most of the fossiliferous layers be deposited during the year of the flood. To recheck all identified fossil reefs would not be an easy task, and would require more than a lifetime. Earlier in this paper reference was made to reports of fossil reefs with frame builders in apparent position of growth. These appear as true autochthonous reefs. However, another alternative that would fit with the creation concept is that some of these reefs grew that might have grown between the time of creation and the flood. They could presently be in the position where they grew, or they may have been massively transported during the upheaval of the flood.

Several investigators have referred to the transport of entire or major parts of reefs (Cook et al. 1972; Heckel 1974; Hodges & Roth 1986; Newell et al. 1953, Plates 14-2 and 15-1). The more recent interpretations of the Nubrigyn and Muleshoe fossil "reefs" discussed above suggest massive transport. Polan (1982) found that assumed autochthonous "bioherms" (reefs) in northern Canada were "blocks derived during catastrophic events." The same kind of reinterpretation applies to "patch reefs" of the Bone Spring Limestone in western Texas (Pray & Stehli 1963).

The new theory of plate tectonics with moving continents and changing ocean floors has added further impetus to concepts of moving reefs. It is a relatively minor event to move a reef compared to moving a continent. In some cases both can be related. For instance, a number of fossil reefs have been described in the Austrian Alps. The Steinplatte described above is one of these. Figure 8 shows another famous fossil reef region of the Austrian Alps. It has long been suggested by geologists that these reefs and their surrounding sedimentary layers came from an ancient Tethys Sea to the south, pushed to the north as Africa moved towards Europe. How far these sediments and their reefs traveled has been a matter of conjecture, but recent estimates (Tollmann 1987) suggest as much as 1000 km.

FIGURE 8. Looking south into the Dachstein Limestone above Lake Gosau in the Austrian Alps. The vertical cliffs, to the right above the lake, are interpreted as a reef complex. Some current interpretations suggest that this entire limestone formation has been transported 1000 kilometers from the south.

Also to be considered within a creation context is the possibility that some fossil reefs formed between creation and the flood have not moved with respect to their immediate surroundings. They are presently located where they grew. An example may be the extensive (Devonian) reef complex of the Canning basin in western Australia (Playford 1980). This complex rests on basement (Precambrian) rocks. Should this complex turn out to be a real autochthonous structure, it may represent a fossil reef that grew during the many centuries before the Genesis flood, and it still rests on the basement rocks where it grew.

CONCLUSIONS

It does not appear that fossil reefs present an undebatable time problem for the biblical scenario of a recent creation. Their identification is often questionable. Many fossil reefs are different from our present reefs, with 1) a different configuration, 2) different kinds of organisms involved in their formation, and 3) a notable absence of the rigid biological framework necessary for producing a real wave resistant reef structure.

These structures could be allochthonous, and as such do not present the serious long-time challenge that slowly growing biological structures present. They could have been formed by various kinds of sediment transport events during the year of the Genesis flood. Some fossil reefs appear to be real autochthonous reefs, and may represent reefs that grew between creation and the Genesis flood. Autochthonous reefs may or may not have been moved during some of the catastrophic changes of that complex flood event.

LITERATURE CITED

Achauer CW. 1969. Origin of Capitan Formation, Guadalupe Mountains, New Mexico and Texas. American Association of Petroleum Geologists Bulletin 53:2314-2323.

Babcock JA, Yurewicz DA. 1989. The massive facies of the Capitan Limestone, Guadalupe Mountains, Texas and New Mexico. In: Harris PM, Grover GA, editors. Subsurface and outcrop examination of the Capitan shelf margin, Northern Delaware Basin. SEPM Core Workshop No. 13. Tulsa, OK: Society of Economic Paleontologists and Mineralogists, p 365-371.

Blatt H, Middleton G, Murray R. 1980. Origin of sedimentary rocks. 2d ed. Englewood Cliffs, NJ: Prentice-Hall.

Bolton K, Lane HR, LeMone DV, editors. 1982. Symposium on the paleoenvironmental setting and distribution of the Waulsortian facies. El Paso, TX: The El Paso Geological Society and the University of Texas at El Paso.

Braithwaite CJR. 1973. Reefs: just a problem of semantics? American Association of Petroleum Geologists Bulletin 57:1100-1116.

Conaghan PJ, Mountjoy EW, Edgecombe DR, Talent JA, Owen DE. 1976. Nubrigyn algal reefs (Devonian), eastern Australia: allochthonous blocks and megabreccias. Geological Society of America Bulletin 87:515-530.

Cook HE, McDaniel PN, Mountjoy EW, Pray LC. 1972. Allochthonous carbonate debris flows at Devonian bank (‘reef’) margins, Alberta, Canada. Bulletin of Canadian Petroleum Geology 20:439-497.

Cotter E. 1965. Waulsortian-type carbonate banks in the Mississippian Lodgepole formation of central Montana. Journal of Geology 73:881-888.

Cys JM, Toomey DF, Brezina JL, Greenwood E, Groves DB, Klement KW, Kullman JD, McMillan TL, Schmidt V, Sneed ED, and others. 1977. Capitan Reef evolution of a concept. In: Permian Basin Section SEPM, editor. Upper Guadalupian facies, Permian Reef complex, Guadalupe Mountains, New Mexico and West Texas. 1977 Field Conference Guidebook. SEPM Publication 77-16:201-313.

Devaney KA, Wilkinson BH, Van der Voo R. 1986. Deposition and compaction of carbonate clinothems: the Silurian Pipe Creek Junior complex of east-central Indiana. Geological Society of America Bulletin 97:1367-1381.

Dunham RJ. 1970. Stratigraphic reefs versus ecologic reefs. American Association of Petroleum Geologists Bulletin 54:1931-1950.

Dunham RJ. 1972. Capitan Reef, New Mexico and Texas: facts and questions to aid interpretation and group discussion. Permian Basin Section, Society of Economic Paleontologists and Mineralogists Publication 72-14.

Giles KA. 1995. Allochthonous model for the generation of Lower Mississippian Waulsortian mounds and implications for prediction of facies geometry and distribution. Annual

meeting, Houston, Texas. American Association of Petroleum Geologists Abstracts with Programs 4:33A.

Gili E, Masse J-P, Skelton PW. 1995. Rudists as gregarious sediment-dwellers, not reef-builders, on Cretaceous carbonate platforms. Palaeogeography, Palaeoclimatology, Palaeoecology 118:245-167.

Ginsburg RN. 1991. Controversies about stromatolites: vices and virtues. In: Miffier DW, McKenzie JA, Weissert H, editors. Controversies in modern geology. London, San Diego and NY: Academic Press, p 25-36.

Hayes PT. 1964. Geology of the Guadalupe Mountains, New Mexico. US Geological Survey Professional Paper 446.

Heckel PH. 1974. Carbonate buildups in the geologic record: a review. In: Laporte LF, editor. Reefs in time and space: selected examples from the recent and ancient. Society of Economic Paleontologists and Mineralogists Special Publication 18:90-154.

Hodges LT. 1987. Fossil binding in modern and ancient reefs. Origins 14:84-91.

Hodges LT, Roth AA. 1986. Orientation of corals and stromatoporoids in some Pleistocene, Devonian, and Silurian reef facies. Journal of Paleontology 60:1147-1158.

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

Hornbacher D. 1984. Geology and structure of Kodachrome Basin State Reserve and vicinity, Kane and Garfield Counties, Utah [MS thesis]. Loma Linda (CA): Loma Linda University.

Hubbard DK, Miller Al, Scaturo D. 1990. Production and cycling of calcium carbonate in a shelf-edge reef system (St. Croix, U.S. Virgin Islands): applications to the nature of reef systems in the fossil record. Journal of Sedimentary Petrology 60:335-360.

Hurley NF. 1989. Facies mosaic of the lower Seven Rivers Formation, McKittrick Canyon, New Mexico. In: Harris PM, Grover GA, editors. Subsurface and outcrop examination of the Capitan shelf margin, northern Delaware Basin. SEPM Core Workshop No. 13. Tulsa, OK: Society of Economic Paleontologists and Mineralogists, p 325-346.

James NP. 1983. Reef environment. In: Scholle PA, Bebout DG, Moore CH, editors. Carbonate depositional environments. Tulsa, OK: American Association of Petroleum Geologists, p 346-439.

James NP, Macintyre IG. 1985. Carbonate depositional environments: modern and ancient. Part 1: Reefs: zonation, depositional facies, diagenesis. Colorado School of Mines Quarterly 80 (3):1-70.

King PB. 1948. Geology of the southern Guadalupe Mountains, Texas. US Geological Survey Professional Paper 215.

Kirkland-George B. 1992. Distinctions between reefs and bioherms based on studies of fossil algae: Mizzia, Permian Capitan Reef complex (Guadalupe Mountains, Texas and New Mexico) and Eugonophyllum, Pennsylvanian Holder Formation (Sacramento Mountains, New Mexico) [PhD dissertation]. Baton Rouge (LA): Louisiana State University.

Kirkland-George B, Longacre SA, Stoudt EL. 1993. Reef. In: Debout DG, Kerans C, Harris PM. Guide to the Permian Reef Geology Trail, McKittrick Canyon, Guadalupe Mountains National Park, West Texas. University of Texas at Austin Bureau of Economic Geology Guidebook 26:23-31.

Ladd HS. 1950. Recent reefs. American Association of Petroleum Geologists Bulletin 34:203-214.

Lang WB. 1937. The Permian formations of the Pecos Valley of New Mexico and Texas. American Association of Petroleum Geologists Bulletin 21:833-898.

Laudon LR, Bowsher AL. 1941. Mississippian formations of Sacramento Mountains, New Mexico. American Association of Petroleum Geologists Bulletin 25:2107-2160.

Lloyd ER. 1929. Capitan limestone and associated formations of New Mexico and Texas. American Association of Petroleum Geologists Bulletin 13:645-659.

Lowenstam HA. 1950. Niagaran reefs of the Great Lakes area. Journal of Geology 58:430-487.

Manten AA. 1971. Silurian reefs of Gotland. Developments in Sedimentology 13. Amsterdam, London, NY: Elsevier Publishing Co.

Mountjoy EW, Cook HE, Pray LC, McDaniel PN. 1972. Allochthonous carbonate debris flows worldwide indicators of reef complexes, banks or shelf margins. Stratigraphy and Sedimentology, International Geological Congress, 24th Session, Section 6, p 172-189.

Newell ND. 1955. Depositional fabric in Permian Reef limestone. Journal of Geology 63:301-309.

Newell ND, Rigby JK, Fischer AG, Whiteman AJ, Hickox JE, Bradley JS. 1953. The Permian Reef complex of the Guadalupe Mountains region, Texas and New Mexico: a study in paleoecology. 1972 reprint. NY: Hafner Publishing Co.

Percival IG. 1985. The geological heritage of New South Wales, Vol. 1. Sydney: New South Wales National Parks and Wildlife Service.

Piller WE. 1981. The Steinplatte Reef complex, part of an Upper Triassic carbonate platform near Salzburg, Austria. In: Toomey DF, editor. European fossil reef models. Society of Economic Paleontologists and Mineralogists Special Publication 30:261-290.

Playford PE. 1980. Devonian "Great Barrier Reef" of Canning Basin, Western Australia. American Association of Petroleum Geologists Bulletin 64:814-840.

Polan KP. 1982. The allochthonous origin of "bioherms" in the early Devonian Stuart Bay formation of Bathurst Island, Arctic Canada [MS thesis]. Montreal: McGill University.

Pray LC. 1958. Fenestrate bryozoan core facies, Mississippian bioherms, southwestern United States. Journal of Sedimentary Petrology 28:261-273.

Pray LC. 1965. Limestone clastic dikes in Mississippian bioherms, New Mexico. Abstracts for 1964. Geological Society of America Special Paper 82:154-155.

Pray LC. 1969. Micrite and carbonate cement: genetic factors in Mississippian bioherms. Abstracts of papers to be presented at the North American Paleontological Convention, September 5,6, & 7, 1969. Journal of Paleontology 43:895.

Pray LC. 1977. The all wet constant sea level hypothesis of upper Guadalupian shelf and shelf edge strata, Guadalupe Mountains, New Mexico and Texas. In: Permian Basin Section SEPM, editor. Upper Guadalupian facies, Permian Reef complex, Guadalupe Mountains, New Mexico and West Texas. 1977 Field Conference Guidebook. SEPM Publication 77-16:433.

Pray LC, Stebli FG. 1963. Allochthonous origin, Bone Spring "patch reefs," West Texas. Abstracts for 1962. Geological Society of America Special Paper 73:218-219.

Robertson DS. 1972. The paleoecology, distribution and significance of circular bioherms in the Edwards Limestone of central Texas. Baylor Geological Studies Bulletin 23:15-27.

Rosen BR. 1990. Reefs and carbonate build-ups. In: Briggs DEG, Crowther PR, editors. Palaeobiology: a synthesis. Oxford, London, and Edinburgh: Blackwell Scientific Publications, p 341-346.

Roth AA. 1992. Clastic pipes and dikes in Kodachrome Basin. Origins 19:44-48.

Roth AA. 1979. Coral reef growth. Origins 6:88-95.

Scoffin TP. 1987. An introduction to carbonate sediments and rocks. Glasgow and London: Blackie; and NY: Chapman and Hall.

Scott RW, Fernandez-Mendiola PA, Gili E, Simó A. 1990. Persistence of coral-rudist reefs into the Late Cretaceous. Palaios 5:98-110.

Skelton PW, Gili E, Vicens E, Obrador A. 1995. The growth fabric of gregarious rudist elevators (hippuritids) in a Santonian carbonate platform in the southern Central Pyrenees. Palaeogeography, Palaeoclimatology, Palaeoecology 119:107-126.

Stanton RJ, Jr. 1988. The Steinplatte, a classic Upper Triassic reef that is actually a platform-edge sandpile. Geological Society of America Abstracts with Programs 20(7):A201.

Tollmann A. 1987. Geodynamic concepts of the evolution of the Eastern Alps. In: Flügel HW, Faupl P, editors. Geodynamics of the Eastern Alps. Vienna: Franz Deuticke, p 361-378.

Wengard SA. 1951. Reef limestones of Hermosa formation, San Juan Canyon, Utah. American Association of Petroleum Geologists Bulletin 35:1038-1051.

Wilson JL. 1975. Carbonate facies in geologic history. NY, Heidelberg, and Berlin: Springer-Verlag.

Wolf KH. 1965a. Littoral environment indicated by open-space structures in algal limestones. Palaeogeography, Palaeoclimatology, Palaeoecology 1:183-223.

Wolf KH. 1965b. Petrogenesis and palaeoenvironment of Devonian algal limestones of New South Wales. Sedimentology 4:113-178.

Wolf KH. 1965c. Gradational sedimentary products of calcareous algae. Sedimentology 5:1-37.

Wood R, Dickson JAD, Kirkland-George B. 1994. Turning the Capitan Reef upside down: a new appraisal of the ecology of the Permian Capitan Reef, Guadalupe Mountains, Texas and New Mexico. Palaios 9:422-427.

Wray JL. 1971. Algae in reefs through time. Proceedings of the North American Paleontological Convention, Part J: Reef organisms through time. Lawrence, KS: Allen Press, p 1358-1373.

Yurewicz DA. 1977. Locality guide, Stop IV, lower Capitan-massive inner Slaughter Canyon. In: Pray LC, Esteban M, editors. Upper Guadalupian facies, Permian Reef complex, Guadalupe Mountains, New Mexico and West Texas. 1977 Field Conference Guidebook. Vol. 2: Road Logs and Locality Guides. Permian Basin Section, Society of Economic Paleontologists and Mineralogists Publication 77-16:G-57 — G-68.