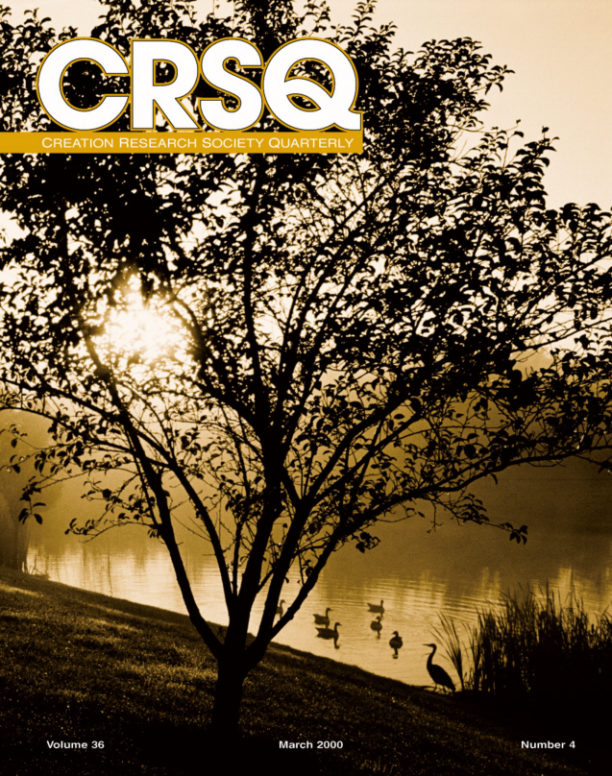


CRSQ



CREATION RESEARCH SOCIETY QUARTERLY

Volume 36

March 2000

Number 4

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Cover design by Michael Erkel
Michael Erkel & Associates
1171 Carter St., Crozet, VA 22932

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The *Creation Research Society Quarterly* is published by the Creation Research Society, P. O. Box 8263, St. Joseph, MO 64508, and it is indexed in the *Christian Periodical Index* and the *Zoological Record*.

Send papers on all subjects to the Editor: Emmett L. Williams, 7312 Club Crest Dr., Flowery Branch GA 30542. Send book reviews to the Book Review Editor: Don B. DeYoung, 200 Seminary Dr., Winona Lake IN 46590.

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Published with Corel Ventura and Adobe Acrobat.
Printed in the United States of America.

Haec Credimus

For in six days the Lord made heaven and earth, the sea, and all that in them is, and rested on the seventh.—Exodus 20:11

Editor's Comments

Jerry Akridge discusses the possible development of a waterfall in Alabama from a creationist young-earth perspective. Possibly you may not have any interest in the formation of a specific waterfall, but Akridge offers some speculation on how these scenic geomorphic features may have formed under similar geologic circumstances which may pique your curiosity.

Dark matter is the topic of an article by the president of the Society, Don DeYoung. This esoteric subject is explored from many angles and the author's conclusions may surprise you. Is dark matter real or imaginary? We actually know very little about the universe in which we live.

A very complex example of parasitism is presented by Mark Armitage. The amazing details of this situation indicate that planning and design probably were necessary to establish the parasite-host relationship. It is unlikely, therefore, that trematode parasites could have originated by stochastic means. Darwinism is ruled out by clear thinking, but did the Creator design these parasites for other functions before the Fall of man? So often in scientific investigation "there are more questions than answers", and conclusions may be no more than speculation. But humans seldom will acknowledge this limitation of their perceptive abilities.

Jerry Bergman deals with the insurmountable problem of the origin of life from nonliving material by naturalistic

means. This leap of faith by evolutionists to believe that such a thing could happen is astounding, and it illustrates to what ends men will go to avoid the implication of a Creator ruling the cosmos. The hypothesis that a "spark of life" spontaneously generated on properly-arranged complex molecules is examined historically and scientifically by the author.

The topic of speleothem growth in caverns was the subject of an ongoing research program in the 1970s. George Matzko has revived this study and approaches it from a theoretical standpoint, bringing together old data with newly-generated kinetic and age-dating techniques. More scientists realize that speleothem growth can be quite rapid under the proper conditions. Equipment has been constructed at the Research Center in Arizona to continue the experimental activities. It is hoped that theoretical predictions and actual laboratory studies can be dovetailed into a successful effort.

Shorter dissertations on fossil man and rock spires on Lookout Mountain may interest you. You are welcome to write to the editor about any topic covered in this issue. I hope you enjoy the diverse contents of the March *Quarterly*.

Emmett L. Williams
Editor

Book Review

Subterranean by James Rollins
Avon Books, New York. 410 pages, \$7 paperback

This novel is the first book written by veterinarian and spelunker (cave explorer) James Rollins. A *New York Times* best seller, the novel illustrates what millions of Americans are reading. The story concerns a fictional cave complex found deep beneath the Antarctic ice. Underground there are mile-size caverns, rushing rivers, and ancient cliff dwellings. Even stranger are subterranean flocks of birds, energized and illuminated by glowing minerals. Vicious dinosaur-like monsters terrorize the explorers.

The collision hypothesis is offered for the demise of most dinosaurs (p. 101). In Rollins' imagination, prehistoric creatures have somehow continued to survive underground for 65 million years. Further confusion results from the comment that underground artifacts are carbon dated at 5.2 million years (p. 26). In practice, the carbon-14 technique is limited to just thousands of years. Author

Rollins has a background in evolutionary biology. His novel uniformly promotes such thinking. For example the cave creatures are all monotremes, including secretive aboriginal beings. Monotremes are "primitive" mammals which lay eggs (p. 246). Thus evolution somehow took an entirely different branch in the underground. There are also new age intimations: the aboriginal shamans are able to read minds and to tell the future.

Subterranean joins the current series of *Jurassic Park* and *Star Wars* stories. All portray "prehistoric" creatures living together with modern people, less fictional than the authors could possibly imagine.

Don B. DeYoung
Grace College
200 Seminary Drive
Winona Lake, IN 46590

DeSoto Falls in DeSoto State Park, Alabama: Evidence for Recent Formation?

A. Jerry Akridge*

Abstract

Uniformitarian geology is based on long periods of time which are demanded for the formation of geomorphic features found on Earth. According to this doctrine, most extant geomorphic structures required millions of years of slow and gradual processes for their formation (Dunbar, 1955). In contrast to this, the Young-Earth Flood model predicts that these features were formed within the last few thousand years while undergoing the effects of

high-energy, short-term, catastrophic processes (Gish, 1985). Conditions which favored rapid modification of the Earth's surface were present during the period of the Flood Event and the subsequent Ice Age (following the geologic framework proposed by Froede, 1998). DeSoto Falls, located in DeSoto State Park, Alabama, is such a geomorphic feature that is best explained within the framework of the Young-Earth Flood model.

Site Location

DeSoto Falls is located within DeSoto State Park near Mentone, Alabama (Figure 1). This waterfall was formed by the west fork of the Little River which flows atop Lookout Mountain.

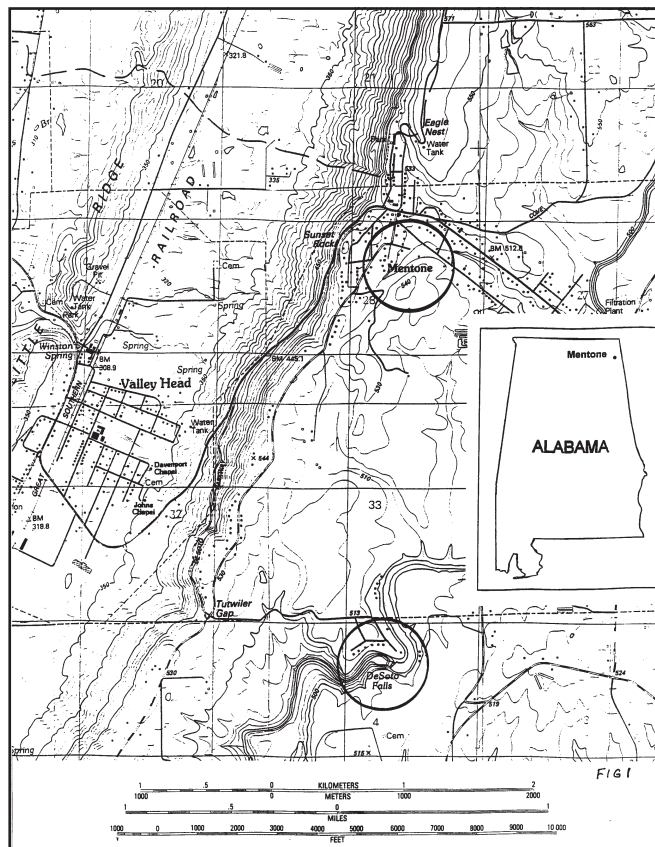


Figure 1. Map showing the location of DeSoto Falls in DeSoto State Park near Mentone, Alabama.

Description of Lookout Mountain

Lookout Mountain is the narrowest synclinal plateau within the Appalachian Plateaus Province of Alabama. It extends in a northeast to southwest direction from Chattanooga, Tennessee, to Gadsden, Alabama, a distance of approximately 80 miles (127 km) (Figure 2). The plateau varies in width from an approximate maximum of 10 miles (16 km) to a minimum of one mile (1.6 km). Compared to the long anticlinal valleys adjacent to and paralleling Lookout Mountain, the topographical relief is approximately 1,600 feet (488m). This syncline is capped by sandstone which is considered by uniformitarian geologists to be Pennsylvanian in age. This sandstone is part of the Pottsville Formation which covers much of north Alabama (Osborne, et al., 1989).

Description of the West Fork of the Little River

One of the major tributaries in the drainage basin associated with this part of Lookout Mountain containing DeSoto Falls is the west fork of the Little River. This river is approximately 25.3 miles (40.7 km) in length from its origin to its conjunction with the east fork of the Little River. Water flow in the tributary varies from almost none in dry weather to a heavy discharge during wet conditions. In its meandering, southward course, the tributary approaches within approximately 1,200 feet (366 m) of the western

*A. Jerry Akridge, B. Sc., 2626 Pine View Drive, Arab, Alabama 35016-4548]

Received 13 September 1999; Revised 20 October 1999

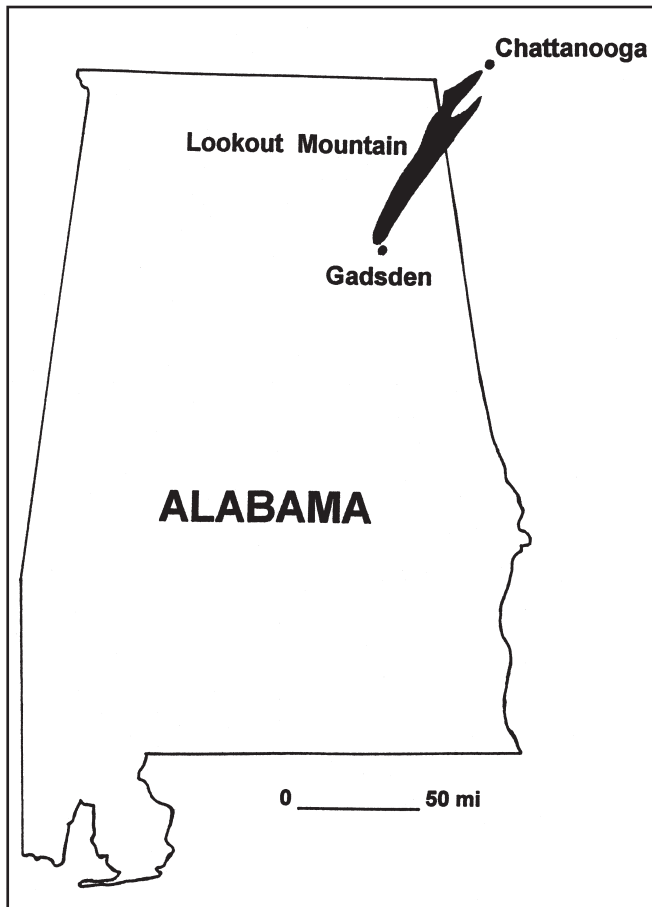


Figure 2. Map showing location of Lookout Mountain between Gadsden, Alabama, and Chattanooga, Tennessee.



Figure 3. View looking down canyon from the lip of DeSoto Falls with a small part of plunge pool visible in lower right. The south side of the cirque-shaped basin is seen on the left. The sheer cliff faces of the canyon of the west fork of the Little River are barely discernible through the heavy vegetation. The underfit west fork of the Little River can be seen exiting the catchment basin at the uppermost part of the plunge pool. Note people on light-colored area in lower right for scale.

margin of Lookout Mountain and approximately 4,000 feet (1.2 km) from its eastern margin. The gradient of the tributary is 834 feet (254 m) from its origin to the point of intersection with the east fork of the Little River. The west fork of the Little River exhibits the characteristics of an underfit stream in that it is too small to have carved the canyon through which it flows.

The Canyon of the West Fork of the Little River

A canyon, cut entirely from undifferentiated Pottsville Formation sandstone and varying in depth up to approximately 180 feet (54.9 m), hosts portions of the west fork of the Little River. The canyon has sheer cliff faces which drop 50 feet (15.2 m) or more before the talus apron is reached (Figure 3). Talus accumulation is minimal throughout the course of the canyon.

Description of DeSoto Falls

From its location on the west fork of the Little River, DeSoto Falls (Figures 4a and 4b) is approximately 9.3 miles (15 km) upriver from the conjunction of the east and west forks of the Little River. DeSoto Falls, comprised of a major and minor waterfall, provides an abrupt change in the topographical relief of the west fork of the Little River. The major waterfall measures approximately 100 feet (30.5 m). Approximately 75 feet (23 m) upstream from the major waterfall is another waterfall measuring 21 feet (6.4 m). A 19 foot (5.8 m) high dam spans the west fork of the Little River approximately 90 feet (30.5 m) upstream from the minor waterfall. Water flow in Figures 4a and 4b is about the maximum normally observed except during rare and unusually wet conditions.

DeSoto Falls plunges into a cirque-shaped catchment basin which is approximately 375 feet (114 m) in diameter. The plunge pool occupies most of the diameter of the catchment basin and is 35 feet (10.7 m) deep directly under the waterfall (Thomas, 1998). DeSoto Falls faces almost due west and is positioned approximately 4,700 feet (1.43 km) from the western margin of Lookout Mountain. The sides of the catchment basin have a maximum relief of approximately 180 feet (54.9 m) measured from the elevation of the plunge pool (Mizener, 1998).

An Anomaly of the Cross-Sectional Profile at DeSoto Falls

There are at least two apparent erosional profiles for the west fork of the Little River at DeSoto Falls (Figure 5). The



Figure 4a. Aerial view of DeSoto Falls. Note minor waterfall and cirque-shaped catchment basin.

prominent profile exhibits an erosional pattern in the sandstone which has a flattened, U-shaped cross-sectional profile (Figure 5-A). The other profile is the smaller cross-section (Figure 5-B) formed by downcutting of the sandstone ledge over which the present water flows to form the major waterfall. This rectangular-shaped erosional downcut in the ledge measures 50 feet (15.2 m) wide by eight feet (2.4 m) high and normally contains all of the water flowing over the waterfall except during rare and unusually wet conditions. During periods of moderate rainfall, the water depth at the lip of the falls is usually less than one foot (0.3 m). The amount of water flow in the rectangular downcut varies as the flow volume varies in the west fork of the Little River.

Possible Flood-Based Events Leading to the Formation of DeSoto Falls

This area of Alabama containing Lookout Mountain is within the Appalachian Plateaus and Valley and Ridge Provinces. How the folding and faulting of these strata were accomplished remains an enigma to uniformitarian geologists. However, much of the mystery can be unraveled by creationists in viewing the formation process as occurring rapidly during the high-energy events of the earth-covering Flood and its aftereffects.

During the Flood, large areas of the earth's surface became covered by layers of water transported sediment. Following deposition, the unlithified sediments were apparently subjected to compressional and tensional forces parallel to the Earth's surface and perpendicular to the resulting folds that formed throughout the Appalachian fold and thrust belt. These forces probably began during the later stages of the Flood after the deposition of these immense sediment layers, increased rapidly, and then exponentially decreased in intensity with the waning



Figure 4b. View of DeSoto Falls showing both minor and major waterfalls.

of the Floodwater and associated diastrophism. The unlithified sediments could have been bent and folded without cracking the strata, examples of which can be observed in many locations. When certain conditions, dependent on such factors as compressional/tensional forces, depth of sediments, resultant radii of folding, and the degree of lithification, were present in localized areas of Flood-laid strata, cracks and thrust faulting would have occurred. These factors would have resulted in the folding and faulting of strata which were then acted on by the power of the abating Floodwater.

Lookout Mountain is a narrow syncline bounded on each side by long anticlinal valleys which lie parallel to the synclinal axis of the mountain. During the Flood, compressional and tensional forces caused the formation of this synclinal structure and adjacent anticlines. The anticlines, which were initially higher in elevation than the syncline, were eroded more rapidly than the syncline to form the existing adjacent valleys (Akridge, 1998; Froede, 1997). Al-

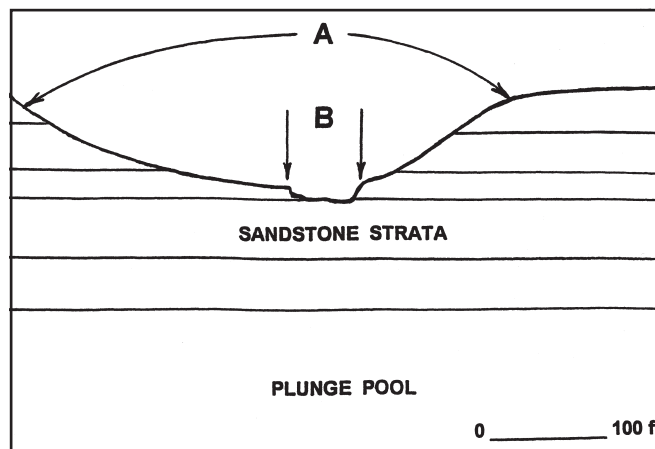


Figure 5. A cross-sectional profile of the west fork of the Little River at DeSoto Falls showing major (A) and minor (B) erosional profiles.

though this striking reversal of the elevations of the syncline and anticlines seems improbable, empirical data demonstrate that this did actually happen, leaving the structures now in existence. Uniformitarian geology does not supply a reasonable explanation of how this anomaly could have taken place. Only the Young-Earth Flood model provides credible answers to the otherwise perplexing mysteries found in these and other Appalachian geomorphic structures.

As the retreating Floodwater gathered kinetic energy during the later stages of the Flood, it would have had tremendous erosive power in carving the Earth's features. As the newly formed syncline and adjacent anticlines were subjected to the erosional assault of fast moving Floodwater, they would have undergone differential erosion. Initially, the elevated anticlines would have offered greater hydrodynamic resistance to the energized water and they would have been eroded at a faster rate than the adjacent synclines. As the anticlines were rapidly worn down, the folded strata which had high angles of dip within the anticlinal structures would be exposed and eroded faster than the syncline (Akridge, 1998). The water would have moved in a direction paralleling the exposed edges of the folded strata which would have had greater susceptibility to erosion than the comparatively horizontal beds of the syncline.

In the area of study, the plateau-like top of the Lookout Mountain syncline dips to the west and south. Floodwater would have flowed across this area in the direction of the slope of the top of the syncline. Once the anticlines were eroded to lower elevations than the syncline, the water would have concentrated its erosive power in the newly forming anticlinal valleys. Thus, the differential rate of erosion would have been amplified with the greater concentration of Floodwater flowing around the syncline at this time during the Flood.

Speculations on the Formation of DeSoto Falls

The drainage basin on top of the Lookout Mountain syncline was likely established by the swift currents of Floodwater. During the later time frame of the Flood, the abating, high-energy water would have been directed through this drainage system, its energy being focused along newly forming downcuts. The semi-lithified strata on top of the syncline underwent rapid downcutting in the areas favoring maximum water flow. Canyons would have been quickly formed in the path of the energetic water. What is now the west fork of the Little River would have been one of the major concentrations for the route of water on its way to a lower elevation. This fast moving water would have been perhaps many tens of feet deep as it

gouged out the canyon and drainage patterns which now contain the west fork of the Little River.

Water flow through this area of interest during the inception of the canyon, coupled with the existing topography, would have established conditions favoring the construction of waterfalls at appropriate points in its travel. With the establishment of a drainage gradient directing Floodwater withdrawal across the top of the synclinal ridge, conditions would have been optimum for the enhancement and development of erosional scarps later remaining as waterfalls throughout the drainage basin and canyon system of Lookout Mountain. While this paper is written mainly as a treatise on one major waterfall (DeSoto Falls), I propose that other waterfalls within this area may have also been established by the same processes in effect at the time of large-scale canyon formation.

As huge volumes of water surged at high velocities over sudden relief changes in the rapidly forming canyon which now hosts the west fork of the Little River, the erosional rate at and near the relief changes would be greatly amplified. The high velocity water would change from a more laminar flow to become increasingly turbulent as it entered the zones of relief change. This very turbulent water would propagate powerful forces which could have dislodged fragments from the rock forming the relief changes and multiply the rate of erosion by the impact and abrasion by these fragments with the surrounding rock. When water flow is greater than 30 ft/sec (9 m/sec), cavitation can be produced. As vapor bubbles produced from the effect of cavitation implode in contact with rock in the path of the water, a powerful erosive agent is introduced which can hammer on the affected rock with a force of up to approximately 440,000 lb/in² (31,000 kg/cm²) (Barnes, 1956). Thus, cavitation impacts could have quickly eroded large quantities of rock in the path of the energized water (Holroyd, 1990a, b).

As tens of feet of water flowed over erosional scarps which would later become waterfalls, powerful eddies would have been generated which would erode the foot of the relief changes such that undercutting of these structures would be accomplished. Once enough of the underlying strata was undercut, failure of the upper portions of the ledges would have resulted, causing the ledges to break off and the cycle to be repeated in an upgradient portion of the strata. This is believed to have been one of the main causes of erosional retreat of the waterfalls formed by these processes.

Initially, what is now DeSoto Falls would probably have been located many miles downstream from its present position. Due to massive amounts of headward erosion during the formative processes described above, the erosional retreat of the structure could have been as much as tens of feet per hour. For example, during the Lake Missoula Flood, it is postulated that in a week of flooding, Palouse

Falls, a 180 foot high (54.9 m) feature, would have had an erosional retreat from its beginning at the Snake River of 180 ft/hr (54.9 m/hr) [Austin, 1992]. The 400 foot deep (122 m), six mile (9.7 km) long Palouse Canyon and Palouse Falls were apparently formed within this short time frame by the same catastrophic type of erosion believed to be responsible for DeSoto Falls and the related canyon.

Significance of the Cross-Sectional Profile at DeSoto Falls

As discussed earlier, the Floodwater would have initially flowed across the Lookout Mountain syncline and adjacent anticlines in similar volumes. With the erosion of the anticlines and the subsequent reduction in elevation of the anticlines below the level of the synclinal plateau, greater amounts of water would have been diverted through the newly forming anticlinal valleys and away from the higher elevation of the plateau. At the point in time when the anticlines became lower in elevation than the syncline, I believe that the major erosional work in forming the main cross-sectional profile (Figure 5-A) of the canyon at DeSoto Falls was accomplished.

With the detour of major volumes of water through the anticlinal valleys and away from the synclinal plateau, the large cross-sectional profile (Figure 5-A) would have then undergone minor erosional modification as compared to its catastrophic beginning. The reduced water flow from that point in time would serve as the erosional agent in forming the rectangular downcut (Figures 5-B and 6) on the lip of the major waterfall. Large amounts of rainfall and abnormally wet years subsequent to the Flood during the Ice Age would have supplied heavy water flow through this tributary basin, further enhancing erosion of the rectangular downcut. This rectangular downcut, along with the major erosional profile of the canyon, now represent the effects of a much greater water flow than is observed now.

Evidences for the Recent and Cataclysmic Formation of DeSoto Falls

Many evidences speak of DeSoto Falls and its host canyon being of relatively recent origin. Waterfalls are recognized as short-lived features in the existence of a stream (Leet and Judson, p. 235). By their very nature, waterfalls are hurrying their own demise in that their concentrated erosional energy seeks to smooth the sudden drop of a waterfall to a gradual descent in the longitudinal profile of a stream.

The canyon containing DeSoto Falls has vertical side-walls until the talus slope is contacted. Vertical cliffs indicate formation in the relatively recent past as insufficient



Figure 6. The rectangular downcut on the lip of DeSoto Falls which normally contains all the water going over the waterfall. The downcut extends from just below the fence in the upper right to the sandstone shelf on the left. This photo taken during a drought when only a small amount of water flow present. The plunge pool is visible in the catchment basin above the lip of the falls. Four foot (1.2 m) fence provides scale.

time has elapsed for erosion to smooth the cliff scarp to a shallower angle. Also, the presence of minimal talus along the steep canyon walls is an indicator of recent origin. Given the uniformitarian model of millions of years of erosion, there should be no waterfalls present as erosion would have occurred evenly across the surface of the syncline. Additionally, the talus volume should be much greater, with talus extending upward to the formerly steep cliff edges which would be but gentle undulations in the topography.

This logic can also be applied to the sheer catchment basin walls which are shaped similar to a huge cylinder that has been turned vertically on its end. Given time, the catchment basin would be eroded such that the structure would tend to resemble a large wash bowl with shallow sloping sides. In this scenario, DeSoto Falls would not exist, its former vertical structure having been reduced by erosion such that water in what is now the west fork of the Little River would enter this area flowing over gentle slopes.

If a stream is the only agent responsible for valley formation, one can predict that the result would be a vertical-sided gorge which is no wider than the channel of the stream (Leet and Judson, p. 234). This canyon supplies evidence of a large current of water (the original "stream") having carved the canyon through which it coursed. There was insufficient time for the effects of slope wash and mass movement to be primary factors in eroding the canyon walls such that they sloped upward and outward from the stream channel as modern examples demonstrate operating under uniform conditions. When huge volumes of

Floodwater assuaged after a short period of high-energy catastrophic action, the canyon was left much as it remains today. The canyon then became subject to relatively minor erosional modification by the effects of the wet post-Flood Ice Age and the introduction of recent uniform processes.

While the vertical walls of the canyon and catchment basin both speak of recent formation, they also indicate that cataclysmic forces were at work during this same time frame. The catchment basin and canyon are both geomorphic features which could not have been carved by present day levels of water movement as postulated by uniformitarian geologists. The catchment basin has been undercut around much of its base at the elevation of the plunge pool (Figure 7). This undercutting was probably caused by the effect of erosion as high volumes of swirling, sediment-laden water poured over this sharp relief change during the later stages of the Flood, and extending into the wet weather conditions of the Ice Age. Today, the relatively minor turbulent action and low sediment load of swirling water from the waterfall cannot significantly impact or erode the catchment basin. Much of the undercut feature is now protected from further significant erosional modification by a talus dike cover (Figure 7).

Because there is minimal talus accumulation, it is apparent that a large volume of sandstone has been removed from the canyon during its formation. Once eroded, the talus was flushed from the canyon and deposited somewhere beyond modern discovery. The Flood is the only recorded source of energized water that could have accomplished such a task given minimal time in relatively recent history.

Conclusion

The physical evidences for the formation of DeSoto Falls and its host canyon favor a rapid origin within the past few thousand years by hydraulic forces not now in effect. The data collected in this study support an interpretation within the Young-Earth Flood model with continuing post-Flood modification of the features during the time of increased precipitation and wet weather in the subsequent Ice Age.

Erosion which occurred during the Flood appears to have had the greater effect on this topography. However, features in this area seem to indicate that lesser, but significant erosion did also occur during the wet period following the Flood. The rectangular downcut on the lip of the major waterfall is one evidence which strongly supports this interpretation.

The physical evidences found here directly contradict the uniformitarian presuppositions of up to 300 million years of time said to be necessary for the origin of the can-



Figure 7. Undercut areas of DeSoto Falls' catchment basin at the elevation of plunge pool. Note talus dike now protecting undercut areas from significant erosion. Person on rock in water provides scale.

yon and waterfalls. The locale has a youthful appearance that speaks of high-energy erosional processes which were introduced quickly, accomplished their work rapidly, and were attenuated exponentially over a short time frame. After the Flood and the Ice Age, the forces which were responsible for the catastrophic modification of this area had ended, allowing the more uniform processes to begin their erosional work. This would be predicted by the Young-Earth Flood model.

DeSoto Falls and its host canyon stand as a visible and strong testimony of the power and effect of a hydraulic cataclysm which impacted the area in the relatively recent past. Because the geomorphic features in this area support an interpretation based on the Young-Earth Flood model, continued study of this interesting area of Alabama by creation researchers is encouraged.

Acknowledgments

This research was prompted by the encouragement of Dr. Emmett L. Williams while we visited the site in January, 1998. Appreciation is expressed to Mr. Carl R. Froede, Jr., for his helpful comments on the first draft of the manuscript. I wish to thank the reviewers for their time and appropriate suggestions. Mr. Ralph Mizener, manager of DeSoto State Park Information Center and Store, provided invaluable assistance in this research by generously sharing knowledge gained by his many years of study of the area. Also I extend appreciation to my wife, Lucky, who has been a wonderful helpmate on the many field trips to the site. This research would have been an arduous and nearly impossible task without her loving and faithful support.

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Book Review

Tornado in a Junkyard, by James Perloff

Refuge Books. P.O. Box 191, Arlington, MA 02476-0002. 1999, 321 pages, \$ 16.95

James Perloff has aimed at the layman in writing this book and as such includes mild warnings such as the material “is full of technical words” (p. 33). He also throws in layman-friendly words such as Bozo, fiddlesticks, blooey, nah, and oh yeah, and phrases such as “Whoa! Here comes a Nolan Ryan fastball” (p.31), and “Come on, gimme a break!” (p.170). Although this style may be disconcerting to someone expecting a “college-level” dissertation, Perloff has succeeded in presenting a number of analyses about aspects of the creation/evolution controversy without losing the layman reader.

Some might argue that he has gone too far in his attempt to align himself with the masses. For example, in his second chapter he says,

This book will examine the growing case against evolution. That means we’ll deal with—ugh—“science stuff.” But we’ll try to keep it simple and interesting, like those *Dummies* books (p.8).

The book’s title, of course, comes from Sir Fred Hoyle’s famous quote that the probability of higher life forms emerging by chance are comparable to the odds that “a tornado sweeping through a junk-yard might assemble a Boeing 747 from the materials therein” (p.74).

Perloff says “all but a few of my quotes come from evolutionists” (p.23), and this is easily verified by a look at his

“Notes” on page 281 where avowed evolutionists are noted most often, followed by creationists and a few such as Behe and Denton who tell of the extensive problems with evolution but do not fully accept creationism.

The author has included far more illustrations (83) than have most other creationist writers in a book this size and this fact will appeal very much to the layman he is trying to reach.

Several books recently have referred to the Scopes trial and its negative aspects for creationism. In a chapter titled, “Trial by Hollywood,” Perloff gives details of the trial not often seen in creation/evolution literature. He gives the true account of the Scopes trial as contrasted with the movie version called “Inherit the Wind.” Perloff cites at least 23 instances in which the movie sharply disagreed with the facts of the trial.

Perloff has used a unique approach by his extensive use of colloquial language but, hopefully, it will be an effective method to bring the creation viewpoint to those who otherwise might never read about it.

Clifford L. Lillo
22953A Nadine Circle
Torrance, CA 90505

Dark Matter

Don B. DeYoung*

Abstract

Dark matter has never been directly observed. Its presence is indicated by unexplained gravitational effects on stars and galaxies. It is sought within galaxies, in galaxy clusters and throughout space. Surprisingly, dark matter appears to comprise the bulk

of the entire universe. This article surveys the evidence along with possible micro and macroscopic dark matter candidates. The entire idea is then evaluated from the creation perspective. There are also theological implications.

Introduction

Astronomy is sometimes presented as successfully having answered the most basic questions about the universe. One popular book attempts to explain the complete evolution of the universe to within 10^{-43} seconds of its origin (Hawking, 1996). This number is called the *Planck time*, when some cosmologists think the present laws of physics originated. In truth, of course, many fundamental questions remain. We actually know very little about our neighboring planets, and much less about the deep space beyond. Consider just a few of the mysteries in modern astronomy:

- Origin of the moon
- Star and galaxy formation
- Source of cosmic rays
- Nature of quasars and their distances
- Absence of evolved life elsewhere
- Dark matter

The last entry is explored in this article. Dark matter is so called because it emits no detectable radiation. In our current understanding of astronomy and physics, dark matter must comprise the majority of mass in the universe, between 90–99 percent. Yet it has never been detected with certainty, if it indeed exists. Carl Sagan described it as dark, quintessential, deeply mysterious stuff wholly unknown on earth (Sagan, 1994, p. 399). Astronomers therefore have no idea of the composition of the bulk of the entire universe. So much for a fundamental understanding of the physical universe! Dark matter is an apt topic for review and for a creationist evaluation. There is a large number of dark matter discussions and references currently available on the internet.

What Dark Matter is *Not*

The term *dark matter* does not refer to dark nebulae. These are abundant interstellar clouds of dust, which block the light from background stars, and therefore appear as dark silhouettes. Nearby examples include Orion's Horsehead nebula, the Great Rift in Cygnus and the Coal Sack near the Southern Cross.

Some students of the Bible have described a particular dark region in the northern sky. This is further proposed as the literal direction toward heaven. The idea is based on Job 26:7 which describes the north stretched out "over the empty place." However, there is no such northern region of space which is devoid of stars or galaxies. The Job reference simply describes the vastness of space in which stars exist, including the northern sky (DeYoung, 1986).

Neither does dark matter refer to dark line spectra. Stellar light spectra typically show dark lines where certain wavelengths have been absorbed by the star's own atmospheric gases. Also, dark matter does not refer to black holes. Finally, dark matter does not involve Olber's paradox, the profound question of why the sky is dark at night, in spite of seemingly endless stars.

The Location of Dark Matter

There are several alternate names for dark matter including missing mass, hidden matter, shadow matter and hot or cold dark matter. Why is it thought to exist and where must it be located? Dark matter will be discussed in three hierarchical categories. It is sought first within single galaxies. Next, the invisible material is thought to "glue" galaxy groups or clusters together. Finally, popular versions of the big bang model require immense amounts of dark matter existing throughout space. These three reservoirs for dark matter will be considered in the following sections.

*Grace College, 200 Seminary Drive, Winona Lake, IN 46590. DBDeYoung@Grace.edu.

Received 17 September 1999; Revised 30 October 1999

Single Galaxies

In our solar system, inner planets travel faster than the outer planets. Mercury has an orbital velocity of about 107,000 miles/hour (172,000 km/h), while Pluto's velocity averages nearly ten times less, only 10,000 miles/hour (16,000 km/h). This variation in speed follows directly from Kepler's third law of planetary motion,

$$T^2 = \frac{4\pi^2}{GM} r^3 \quad (1)$$

$$v = \sqrt{\frac{GM}{r}} \quad (2)$$

Here T , r , and v are the planet's orbital period, average radial distance from the sun and velocity. G is the universal gravity constant and M is the solar mass.

The stars within galaxies also experience orbital motion. In this case, however, the main gravitational mass is not concentrated at the center as in the solar system. Instead, stellar masses are spread throughout the galaxy, with vast orbits about the center. Isaac Newton proved that for such orbits, only mass lying within a star's orbit affects the star's motion. The gravity force from external mass cancels completely. This is exactly true only for a uniform spherical or circular distribution of mass. However a galaxy provides a fair approximation, including the disk-shaped spiral galaxies.

Equations 1 and 2 can be applied to an entire galaxy of revolving stars. Each star responds to the total gravitation of the partial mass of the galaxy that lies within its orbit. And it is exactly as if this mass were all positioned at the center of the galaxy. The orbital velocity of a star can be measured from the Doppler shift of its light. If the star is near the outer edge of a galaxy, taking r as the galaxy radius and knowing v , equation 2 then gives the total mass M of the galaxy. And here a major problem arises. In every case, the calculated galaxy mass is at least 5–10 times the mass of all the visible stars and other matter in the galaxy. This missing mass component is considered to be invisible dark matter.

There is a second way to look at the mass problem with spiral galaxies. One can plot a *rotation curve*, a graph of velocity versus distance from the galaxy center for component stars. Equation 2 shows that, for the solar system, planet velocity decreases as the inverse square root of distance from the sun. Because of the mass distribution of a spiral galaxy, equation 2 is not followed precisely. However, star velocities should still decrease as their outward distance increases. Instead, however, measurements show *flat* rotation curves for galaxies (Figure 1). That is, the orbital velocities of remote galaxy stars are largely constant, or even *increase* slightly with distance. The unexpected nature of the rotation curve was first noted by astronomers Vera Rubin and Kent Floyd in 1970, for the Andromeda

galaxy. Said in another way, the outer galaxy stars revolve unexpectedly fast. If galaxies are stable, this implies a large amount of dark matter affecting stellar motion. Otherwise, spiral galaxies should be flying apart. One possible mass distribution is a giant halo of invisible matter surrounding and permeating entire galaxies. X-ray telescopes, including *Rosat*, have shown possible evidence for this halo around the Milky Way. However the question remains, how can 90 percent of galaxy mass remain invisible to optical telescopes?

Galaxy Clusters

The terms *missing mass* and *dark matter* were first suggested in 1933 by Cal Tech astrophysicist Fritz Zwicky. He observed the Coma cluster, a group of at least 1,000 galaxies located 400 million light years distant. These galaxies are assumed to be gravitationally bound together. Zwicky noticed that the galaxies had random velocities, and moved much faster than expected. In fact the galaxy cluster should have disintegrated by now. This anomalous motion is likewise true of our own *local group* of galaxies. This local group consists of the Milky Way, Andromeda, Magellanic Clouds and about 30 other galaxies, all lying within about a three million light year region.

Why have not these galaxies within clusters escaped from each other? As before, an invisible binding mass of galaxy groups is considered as dark matter. The galaxy motions suggest that the dark matter mass totals at least ten times that of all the visible galaxies. This shortfall in mass is much greater for the galaxy clusters than that within individual galaxies. The Coma cluster is found to be 90 percent missing. Another example, the Virgo cluster is 98 percent missing. That is, there is assumed to be 50 times more mass than is actually observed. Figure 2 is a photo-

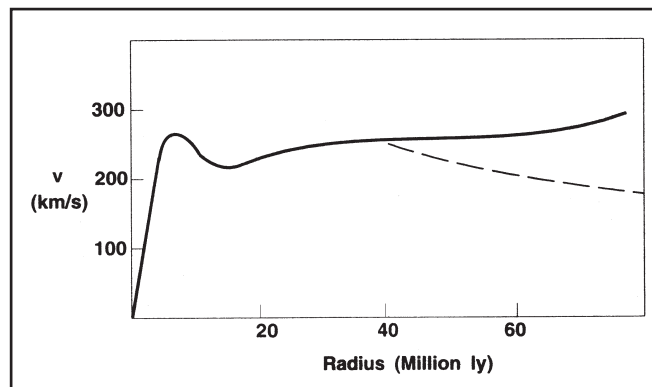


Figure 1. A schematic rotation curve for a typical spiral galaxy. The dashed line shows the trend of star velocities expected from Equation 2, if most of the mass of the galaxy were within 40 million light years of the center. The solid line shows actual measurements (Hawley and Holcomb., 1998, p. 390).

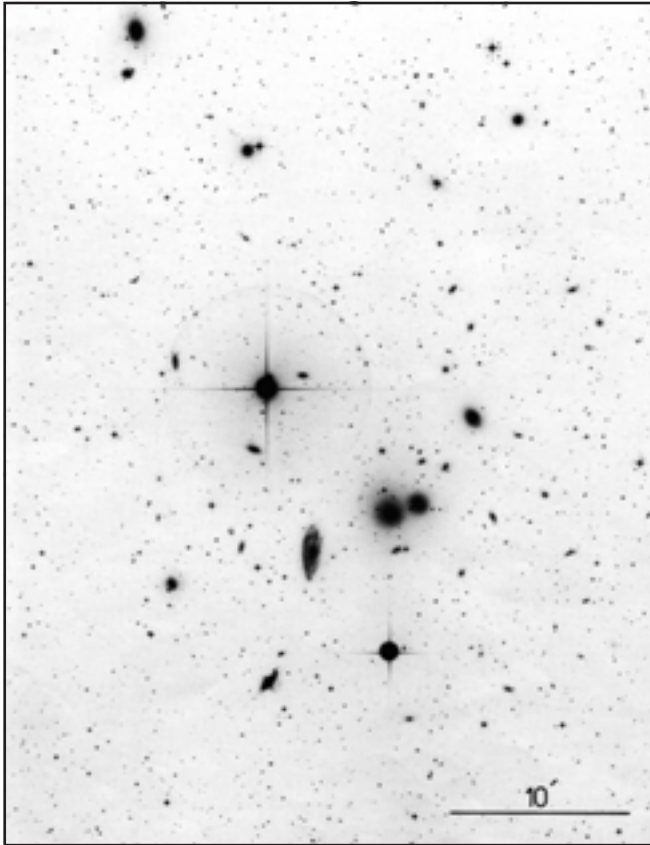


Figure 2. The central part of the galaxy cluster Abell 1060. The photo is from the Royal Observatory, Edinburgh, England (Bruck, 1990, p. 96).

graph negative of the center of the galaxy cluster Abell 1060. The smaller pinpoints of light are nearby Milky Way stars. The spirals and elliptical galaxies shown in the figure are a few of Abell 1060's two hundred galaxy members. The cluster is about 220 million light years away.

Visible gas clouds within galaxy clusters also have added to the dark matter requirement. X-ray observations reveal vast clouds of hot, low-density gas within the clusters. Elsewhere, similar clouds appear to suffuse regions of space far from galaxy clusters. These energetic gas molecules are moving so fast that the observed clouds would quickly leak away and dissipate on an evolutionary time scale. It is therefore concluded that the clouds must contain much more matter than we see, binding them together.

In several cases, *gravitational lenses* appear to give multiple images of the same quasar. Quasars are thought to be far distant, very bright sources of light. Apparently, separate light signals from a distant quasar can be bent by an intervening galaxy and then directed toward the earth. In some cases the light-deflecting galaxies also can be seen. On a more local scale, similar gravity lensing sometimes appears to occur for stars within or near the Milky Way galaxy. However in these cases there is no observed intervening object. Dark matter is suggested as the cause of this light

deflection. Several gravity lens surveys are currently underway. It is hoped that positive results may help determine the *size* of dark matter objects (Holz, 1999).

Virial Theorem

The *virial theorem* can be used to calculate the mass of a single galaxy or a galaxy cluster. It applies if a system is gravitationally stable, without collapse or disintegration taking place. The theorem states that the total gravitational potential energy of the star system equals exactly twice the total kinetic energy. If this condition is not met, the component objects either will cascade inward or escape, depending on the direction of imbalance.

From the virial theorem comes the mass formula for a galaxy cluster (Bruck, 1990, p. 99),

$$M = \frac{3V^2 R}{G} \quad (3)$$

Here V is the average of the squared radial velocities observed for member galaxies within the cluster. R is an estimate of the geometric radius of the entire cluster and G is the gravity constant.

As an example, consider Abell 1060, a cluster of about 200 galaxies located 220 million light years away (Figure 2). Its V is about 7.14×10^5 m/s (0.24% light speed) and R is 6.1×10^{22} m (6.5 million light years). The virial mass result is 14×10^{44} kg, or about 7×10^{14} solar masses. If there are 200 galaxies, each then averages 3.5×10^{12} solar masses. This is about 10 times higher than the known mass of Andromeda and the Milky Way galaxies. The Abell 1060 galaxies probably do not contain this much extra mass. Instead the mass may exist as dark matter spread between the galaxies. A similar numerical discrepancy exists for *every* galaxy cluster, assuming they obey the virial condition.

Some astrophysicists have proposed that galaxy clusters are *not* gravitationally bound after all, so the virial theorem does not apply. The use of the theorem to calculate unseen mass has been called "totally unreasonable" (Burbidge, et al., 1999, p. 42). However if the galaxies are disrupting, then the clusters must be far younger than the multi-billion year age usually assigned to them (Bowers and Deemings, 1984, p. 504).

The Universe

Dark matter is also required on the largest scale of all, that of the entire universe. In this case it is tied to versions of the big bang theory in at least two ways. First, dark matter is enlisted to explain the large-scale structure of the universe. In this

view, the initial universe expansion from a singularity must have experienced positional variations in temperature or energy density. This resulted in a “clumpiness” of matter, with subsequent formation of gas clouds, stars and galaxies. The initial clumps grew larger in this way because of the gravity attraction of invisible cold dark matter concentrations.

Dark matter is also involved in the popular inflationary big bang model which predicts that the curvature of the universe must be *flat* (Figure 3). This means that the density of matter is exactly balanced between a universe which eventually collapses (a closed, finite universe), and one which expands forever (an open, infinite universe). The required *critical* density for a flat universe is about 10^{-26} g/cm³. This corresponds to approximately 10 hydrogen atoms per cubic meter of space. Observed density estimates, although crude, lead to a value 10–100 times smaller than the critical density. Therefore a great amount of dark matter is needed to result in a flat, closed universe with zero curvature.

What is Dark Matter?

This is an unanswered question since dark matter has never been directly observed, and may not even exist. Nevertheless, many possible candidates have been suggested (Trimble, 1987). Several will be listed and briefly evaluated here.

Non-luminous stars include primordial black holes; black, brown or red dwarfs; and energy-depleted white dwarfs. An immense number of these unlit stars would be needed to supply the necessary dark matter. If they average 0.1 solar mass and comprise 90 percent of the total known universe mass, then there must be at least 10^{25} such stars. The basic problem is that *none* have been detected and identified with certainty. Surely, such an astonishing number of non-luminous stars easily should be detected with modern instruments. Even black holes themselves remain as theoretical constructs which have not been verified with certainty.

The brown dwarfs are a special case of failed, low mass stars which never ignited their internal nuclear fusion reactions. They are sometimes pictured as large gaseous planets, somewhat like Jupiter. They have also been called MACHOS, or massive compact halo objects. Efforts have been made to detect brown dwarfs indirectly by their eclipsing of normal stars. That is, one watches for a distant star to temporarily disappear when covered. The background starlight might also be distorted in a *microlensing* effect. No clear brown dwarf evidence has been found in this way, in spite of detailed searches (Hawley and Holcomb, 1998, p. 391). There may be many brown dwarf stars, or they may be very rare.

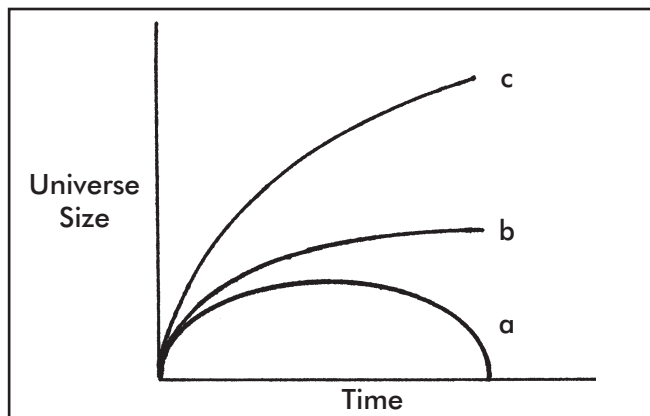


Figure 3. Three views of the expansion of the universe over evolutionary time. The universe is either a: closed, eventually collapsing on itself, b: flat, ceasing expansion after infinite time; or c: open, expanding outward forever.

Diffuse matter would consist of unseen dust or gas particles that are widely dispersed. It has been described as molecular clouds, intergalactic matter, and as halo or coronal material which surrounds and permeates galaxies. The Milky Way contains 10^{11} solar masses. The required invisible dark matter is 100 times greater, 10^{13} solar masses worth. This would be an incredible amount of unseen diffuse matter.

Neutrinos are an abundant product of nuclear fusion, the process thought to energize stars including our sun. Creationists have suggested that gravity contraction may also be occurring within stars (Steidl, 1983). Whatever the combination, some nuclear fusion does occur with resulting neutrino production. From the sun, this sends a continuous flood of neutrinos toward earth with a flux as great as 10^{12} neutrinos/cm² · s.

Solar neutrinos have been detected, although only at about one-third of their expected number. Neutrinos require large, highly specialized detectors since the particles are very elusive and unreactive. Most travel directly through the earth's 8,000 mile diameter without any atomic collisions occurring.

Thus far, laboratory studies of neutrinos show zero mass. However, there is a suggestion that neutrinos might oscillate between different forms as they travel along at light speed. This behavior could mask a vanishingly small but finite mass. With their large abundance throughout space, neutrinos could thus comprise much of the sought-after dark matter. The proposed dynamical behavior for neutrinos might also explain their low abundance as measured from the sun. The problem remains, however, that no one has observed any mass whatsoever for neutrinos. The idea of neutrino mass appears to be a desperate hope for solving the embarrassing mass deficit.

Exotic particles are wisps of localized energy in space that have been theorized but never observed. In physics

jargon, exotic particles are *nonbarionic*. They have much less mass than normal baryons such as neutrons and protons. Exotic particles are often given fanciful acronyms. WIMPS, or weakly interacting massive particles, are predicted by certain theoretical physics models. No one knows whether such dark matter particles exist. Nevertheless, they have been enlisted to help solve the solar neutrino problem. It is proposed that WIMPS inside the sun might help spread heat throughout the solar core. Solar energy could then be generated at a slightly lower temperature, with fewer neutrinos produced than now expected.

A WIMP detector has been built in England, deep underground. It consists of 200,000 liters of pure water. Scientists hope that an occasional WIMP particle speeding in from space might interact with a hydrogen atom in a detectable way. Results thus far have not been encouraging (Seife, 1999).

Axions, whimsically named for a laundry detergent, are another type of hypothesized subatomic particle which contribute mass to space. Other proposed but unobserved particles include photinos, neutralinos, gravitons, mini-black holes and antimatter. Astronomers also speak of *bowling balls*, a shorthand title for ordinary space matter in some hard-to-detect form.

Other exotic particle candidates include cosmic strings or membranes, preons and monopoles. There is certainly no shortage of suggestions to identify dark matter. In reality, however, the dark matter mystery remains completely unsolved after seven decades of intense study.

A Creationist Response

We have seen that dark matter is required if the laws of motion and gravity hold for galaxies, and if galaxy systems are stable. Since creationists are not locked into the big bang theory or evolutionary time, there are several options to consider. They will be discussed here as questions.

Are the laws of nature universal? This question allows for entirely different, unknown laws operating elsewhere in space. Dark matter then might be only an illusion, based on our local understanding of physics. However, there is no reason to expect such an unknowable *multiverse* instead of a *universe*. Instead, light signals coming from deep space, in all the intricate details of their spectra, appear much like light sources within our laboratories. Therefore the dark matter problem cannot easily be solved by rejecting known physics. Newton's and Kepler's laws of motion and gravity appear to be universal in their extent and application.

Are galaxies stable? If dark matter is lacking in galaxies, then over time they will simply disintegrate. This would be a major problem for evolutionary time, since galaxies then should no longer exist. In the recent creation view, how-

ever, little galaxy change would be noticeable since the creation event. After all, galaxies average 100,000 light years in diameter. In just 10,000 years, galaxy enlargement would be minimal.

Still, there is little reason to expect that galaxies are unstable in this way. With few exceptions, mainly within the solar system, transients and instabilities are not found in space studies. Instead, the created universe is marked by great durability. Consider our sun, which has sufficient hydrogen fuel to last for billions of years into the future, although the Creator, of course, may have other plans. Galaxies can be assumed to be stable, and thus must contain some form of dark matter.

Are galaxy clusters stable? Clusters are an entirely separate category from individual galaxies. There is little reason from a creation perspective why these clusters need to be bound together by unseen matter. The Creator may simply have placed these clusters throughout space much as we see them, with random galaxy velocities. Even if unbound, these clusters would only dissipate on a billion year time scale because of their vast size. Galaxy clusters may well be unstable in the long term.

Must the universe be flat? The creation view has no such requirement. The flatness requirement arises only with the big bang theory. The Creator, with equal ease, could have made a closed, flat or open universe. However, I suggest that it may well be open, with a lack of large scale dark matter. The simple reason may be to frustrate all natural origin theories, most of which call for a closed or flat universe. Something similar occurs for the planets. We find sufficient created variety and uniqueness in the solar system to cancel all natural attempts at an explanation, including the popular nebular hypothesis.

What then is dark matter? I have suggested that dark matter exists within galaxies, if not elsewhere. We have considered various physical micro and macro-size possibilities. But there is another option. Perhaps the dark matter we seek is in reality the unseen hand of the Creator. We know from Colossians 1:17 that God in some way holds all things together. Therefore at some point, physical reality must mesh with the spiritual. And that point may lie in the unexplicable problems of modern science.

The law of gravity has been known since it was first explained by Isaac Newton in 1687. On a deep level, however, gravity remains a mystery. That is, we have no idea how objects physically communicate their positions and interact with each other. This ignorance about gravity or dark matter, for both creationists and non-creationists alike, should be a humbling experience. We know very little about physical reality, since we presently "see through a glass darkly" (I Corinthians 13:12). Creationists look forward to the future, when our understanding will be made complete.

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Book Review

The Design Inference by William A. Dembski

Cambridge University Press, New York. 1999, 243 pages, \$59.95

This book is based on the author’s doctoral work in mathematics at the University of Chicago, his post doctorate work in complexity theory at Princeton, and his second doctorate in philosophy at the University of Illinois. Dembski’s work is critical to the creation-evolution controversy because it deals with the essential question “What is the probability that life and the universe are the product of design versus a product of chance?” Creationists often use probability arguments to show the enormous unlikelihood of life evolving by natural law and chance.

A common analogy is the calculation of the likelihood of the body’s 206 bones being placed by chance in the correct order (Bergman, 1999). This analogy, while useful, is limited because life does not result from placing existing structures in the proper order, but is dependent upon many highly improbable events. It is well recognized by creationists and most evolutionists that the probability of life evolving naturalistically is extremely small. In Gould’s famous analogy, if earth’s history were to be replayed “a thousand times,” it probably would not produce the human brain again (Gould, 1989, pp. 233–234).

The application of probability calculations to life’s origin is often obscured by evolutionists who argue that highly improbable events happen every day. Therefore, they argue, because life is highly improbable does not prove that a creator must exist to explain life’s existence. An example which shows that the problem is not the mathematics, but its application was originally discussed by Polanyi (1962, p. 33). Both the chances that 100 stones randomly placed in a garden in any one pattern as well as

to spell “Welcome to Wales by British Railways” are infinitely small. If we are looking for one *special arrangement* of stones only, the likelihood of finding it in thousands of gardens is minuscule unless intelligence arranges the stones in the desired order. Therefore, the likelihood of a meaningful message requires intelligence to produce a specific order of stones. One could spend several lifetimes examining gardens, and the likelihood of finding the phrase “Welcome to Wales, etc.” produced by chance still has a probability of zero.

Mathematics, especially statistics, is a tool that can be used and abused as the classic book by Huff (1953) eloquently demonstrates. A common example used by evolutionists to explain away creationists’ probability arguments is noting the minuscule likelihood of a given assemblage of the specific persons at a creation conference occurring by chance. The problem is an almost infinite variety of combinations will meet our criteria, such as when 100 paid registrations are received, the criteria has been met and the conference will be held. Any 1,000 persons attending meet our criteria, not a certain combination. As a result, the likelihood of the particular combination occurring is not minuscule but one. Conversely, events produced by intelligence require the combination of a *specific* set of events which *as a set* will not occur by chance.

Dembski illustrates how intelligent design can be proven utilizing examples including determining if an electronic signal is random or the result of intelligence. This problem has been worked out years ago in connection with SETI and other programs which attempt to find evidence

of intelligence in outer space based on extraterrestrial radio signals. If the signal contains information defined as non-random data, an intelligent sender is considered probable even if we cannot interpret the information.

As another example, much work has been expended in the area of criminology and forensic science to determine if a set of events has occurred by chance or by design, consequently implicating a suspect. An example is a murder investigation: a man known to have threatened the life of a woman is seen leaving her apartment just after a gunshot is heard. Then five minutes later the victim's husband and son simultaneously enter the apartment and discover the body. The fingerprints on the murder weapon and the victim's blood on his clothes provide evidence which in total is considered overwhelming.

Determining if events are due to intelligent causes or undirected natural causes plus chance is not only the heart of the justice system and extraterrestrial intelligence searches, but many other areas also. An example is determining if an airplane's mechanical failure occurred due to chance, design imperfection, or a deliberate attempt to sabotage the airplane. Dembski shows in detail how decision theory enables us to accurately determine if a series of events such as the above are likely due to chance or to intelligent causes and design.

Dembski concludes that two hallmarks of intelligent causes are (1) specific events occurring which have small probability and (2) the event is specified in advance. Just about everything that happens is highly improbable if chance alone is considered, but when the improbable event is *also specified* i.e., predicted, then judgments about intelligent causation can be made.

Dembski deals with properly classified events as either highly probable or highly improbable. The extreme cases elicit little or no debate from informed adults. Throwing a set of dice and having both turn up sixes 400 times in a row is possible, but most people would be justifiably certain that this result did not occur purely by chance. Likely, design must have intervened i.e., each side of both dices has a six, for example. Conversely, the cutoff point i.e., how small a probability is small enough to eliminate chance, is more difficult.

In an attempt to draw the line, Dembski utilizes many sources such as Emile Borel's basic law of probability which states if the occurrence of an event happening by chance is beyond 1 in 1050 we can state with certainty that this event will *never* happen by chance no matter how much time or how many opportunities exist. The key to his

concept is the *explanatory filter* which involves determining if an event is due to design by ruling out both regularity and chance. If an event is regular such as the result of a law (e.g., gravity), the event will always normally happen and design is not necessary, at least proximally, but may be necessary as a distal explanation. Next, chance must be ruled out. The process of how this is done is the subject of much of Dembski's work.

The key question Dembski tries to answer is, "Is life's emergence and development sufficiently probable to obviate the need for a supernatural designer?" (p. 2). Determining if an event is improbable requires determining how closely it conforms to a pattern, where only one event will meet the criteria. This analysis helps us to determine if an event occurred due to probability or as a result of intelligence.

This brief review in no way does justice to this important book. Dembski's work is critical in the creation-evolution controversy and no doubt will in the future be viewed as a classic which placed the creation worldview on a firm scientific basis. In section 2-3 called "the creation-evolution controversy" Dembski shows why the arguments by Darwinist Richard Dawkins are untenable. While some readers may not want to wade through the mathematical sections, much of the book is assessable to the intelligent lay person. Research in creation is progressing on numerous fronts, and in this author's opinion the core areas which are decisive in falsifying the Darwinian worldview are design inference theory, molecular biology, and genetic research.

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Jerry Bergman
Northwest State Comm.College
22-600 State Rt.34
Archbold, OH 43502-9542

To proceed from the skeptic's perspective in science, philosophy, or any other discipline is anything but neutral; it is inherently anti-theistic and has no more justification as a starting point for intellectual inquiry than does theism.

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Trematode Parasites: What Is Their Genesis?

Mark H. Armitage*

Abstract

An overview of trematode¹ parasitology from the evolution and creation perspectives is presented, including a discussion of the “design-like” features of these parasites. No credible evolutionary explanations are found in the evolutionary literature to account for these “design-like” aspects.

Histological microtechnique for electron microscopy is also reviewed and some cyst ultrastructural data are reported. A caring God may have designed trematodes, now recognized as parasites, to serve other functions before the Fall of man (Genesis 3).

Introduction

The purposes of this study are to review some of the “design-like” behaviors and structures of this group of parasites, to search for a reasonable explanation for their existence in the evolutionary literature, and to provide a creation-based explanation for their origins.

As shown previously (Lumsden and Armitage, 1999), digenetic, heterophyid trematode parasitic worms of the genus *Ascocotyle* infect certain amnicolid snails as first intermediate hosts (such as *Littoradinops*). They also infect certain cyprinodont and poeciliid estuarine fishes (*Cyprinodon*, *Poecilia*, *Fundulus*, *Gambusia*), as second intermediate hosts in a three-step life cycle. The hermaphroditic, adult trematode worms mature in the intestines of definitive hosts, most often piscivorous birds, but also certain mammals such as the raccoon. The *Ascocotyle* group comprises some 30 different species, which vary by mostly minute morphological differences, such as spine count and shape, organ position and size, and organ shape within adults. They also vary in metacercarial cyst shape and thickness, location of infection within the second intermediate host, and the specific host type.

The cyst wall configuration, as observed by TEM (this paper) also can serve as a diagnostic species characteristic. It is on the basis of these morphological features and not reproductive isolation alone that species are identified within this group. These parasites cannot be classified on the single basis of reproductive isolation, as many animal species are, because trematodes are hermaphroditic and several species often inhabit the same estuary.

All of these observed differences are considered by creationists to be at the microevolutionary level of variation, or normal variation within a created kind. The creation model of origins predicts small changes within a kind based on the genome designed by the Creator at the beginning. In contrast, very large scale genomic changes, as espoused by the evolution model of origins, would be necessary to change the *Ascocotyle* worm into a cestode or an annelid, if it could be done at all.

Ascocotyle parasites have been described from Argentina (Ostrowski de Nunez, 1976; 1992; 1993), Brazil (Travassos, 1930), the Caribbean (Price, 1935), Egypt (Looss, 1899), Eastern U.S. (Stunkard and Uzman, 1955; Burton, 1956; 1958; Leigh, 1954; 1956; 1959; 1974; Hutton and Sogandares-Bernal, 1959; 1960; Harkema and Miller, 1962; Miller and Harkema, 1962; Stein, 1968), Gulf Coastal U.S. (Font, Overstreet and Heard, 1984; Font, Heard and Overstreet, 1984; Sogandares-Bernal and Bridgman, 1960; Sogandares-Bernal and Lumsden, 1963; 1964; Lumsden, 1963a, b; 1968), and California (Armitage, 1997b; 1999) but there is a significant paucity of reports of incidence from the Western U.S.

Some workers have reported on the apparent pathogenicity of the *Ascocotyle* genus (Martin and Steele, 1970; Snyder et al., 1989; Font, Overstreet and Heard, 1984; Font, Heard and Overstreet, 1984), but many more have shown large numbers of parasites within infections of no pathogenicity (Stunkard and Uzman, 1955; Burton, 1956; Lenhoff et al., 1960; Lumsden, 1963a; Schroeder and Leigh, 1965; Skinner, 1975; Coleman, 1993; Ostrowski de Nunez, 1993) other than occasional blood flow impediment caused by mechanical occlusion within the heart or

*Mark H. Armitage, M.S., Azusa Pacific University P.O. Box 7000 Mary Hill Center, 101 Azusa, CA 91702-7000

Received 1 August 1999 Revised 25 October 1999

¹This term and other technical terms are defined in a list of definitions at the end of this paper.

the circulatory system. Some significant ultrastructural observations (Lumsden, 1968; Stein and Lumsden, 1971a, b; this paper) using TEM, show that there is absolutely no pathogenicity or host immune response resulting from the presence of the parasite within host tissues. Many workers have even reported that heavily infected snails and fish live for up to a year or more in laboratory aquaria (Leigh, 1956; Stein, 1968; Font, Heard and Overstreet, 1984, and my own observations over many months).

There has been very little discussion by previous workers regarding the complexity of the *Ascocotyle* life cycle (which requires parasitization of three distinct hosts for completion of its life cycle) and what mechanisms may have brought this multifarious system into place. Most, if not all of the evolutionary literature on digeneans in general and ascocotylids in particular fails to develop a credible, empirically-based phylogeny for these organisms.

Some aspects of the *Ascocotyle* life cycle exhibit “design-like” features in behavior, morphology, and structure. These features take the form of behaviors which guide the microscopic parasite to the appropriate host (even in the presence of other fishes), behaviors and sensory papillae which guide the parasite to the appropriate organ for encystment, and specialized structures which allow tissue penetration. There are also other complex structures which control safe passage of the parasite through the digestive or circulatory systems of intermediate and definitive hosts and minimize host immune response.

Workers at the University of California Santa Barbara, have collected some of the same hosts used in this study and have described the actual alteration of host behavior by trematode parasites to ensure predation by the definitive host (Lafferty and Morris, 1996). Their failure to provide an evolutionary explanation for such a highly designed system, however, is evident. Other limited discussions of evolution within the *Ascocotyle* group are offered (Sogandares-Bernal and Lumsden, 1964; Skinner, 1975; Font, Heard and Overstreet, 1984), but no serious explanation has been proposed for how these complex life cycles were initiated and how they arrived at their present state.

The real question is, can parasites be designed? If they can be designed, what would constitute a design feature and how would it be recognizable as such? If certain features are attributed to design, can evolutionary explanations likewise be made for them? If parasites such as *Ascocotyle* were designed, can that design be attributed to a Master-Designer within a Biblical creationist model of origins?

Implications for Creationism

The heteroecious life cycle of the *Ascocotyle* parasite is complex and it clearly shows that it is obligated to a cycle

requiring the timely intervention of at least three different hosts for it to achieve fecundity. Many questions are raised by such life cycles with respect to possible natural selection or environmental pressures which may have driven the *Ascocotyle* parasite (and most trematodes) to seek refuge within these very different hosts in order to reach maturity.

There is no reference in the ascocotylid literature to any significant mechanism which may account for the presence of such complex life cycles, except the usual vague homage paid to an evolutionary “parasite strategy,” and/or “selective advantage.” Some discussion is made in defense of possible evolution-based parasite-host relationships (Sogandares-Bernal and Lumsden, 1964; Yamaguti, 1971; Skinner, 1975; Font, Heard and Overstreet 1984; Lafferty and Morris, 1996), but answers are often speculative. Statements such as Yamaguti’s (1971) prevail:

The present information indicates that the adoption of the parasitic habit occurred at an extremely remote period (of earth history) and that the evolution of parasitic life cycles with accompanying adaptations of the parasites, has proceeded hand in hand with the evolution of their hosts. (brackets mine).

There is no question that worm parasitism has been a part of the biosphere since early times (Poinar, 1984; Ferreira, et al., 1993), and in the creationist model, it certainly pre-dates the Flood. To relegate its origins to a misty past, however, is to avoid the obvious question: Where, when and how did it arise?

The evolutionary-based, trial and error method of adaptation proposed by these authors, fails to serve as an acceptable explanation for the presence of heteroecious life cycles and likewise falls flat in explaining the complex biochemical and sanctuary interactions between these parasites and their hosts. Evolutionary progression would require countless failed random experiments on the part of a parasite to make the transition from a free-living state to life within three completely different host environments, something that an ascocotylid now freely enjoys. Evolution appears to fail in this regard because it cannot be in an organism’s “best interest” to “fetter itself” to another organism, upon which it must depend for its very survival, let alone three different organisms in multiple habitats. Behe (1996) has shown that complex biochemical interactions (which themselves are based upon irreducibly complex biochemical structures) — cannot be formed on a trial and error basis. If these relationships were designed by a Master-Planner from inception, however, then a possible symbiotic exchange may be taking place (or occurred once in the past) and the relationship could be explained on that basis.

Except for one brief note in Smith (1984) describing some alteration of host behavior by parasites, and my recent papers (Armitage, 1997a; 1998; Lumsden and Armi-

tage, 1999), no worker has seriously studied trematodes from a strictly creationist viewpoint. Furthermore, there is no reference in ascocotylid literature which states that a possible positive relationship might exist between this group of worms and their hosts. On the contrary, these infections are often characterized by researchers as merely being benign or minimally harmful (Stein and Lumsden, 1971a, b; Coleman, 1993). This study represents the first attempt to show that these heteroecious life cycles and specialized structures are too complex to have developed by chance, and to present a creationist design argument for the presence of such parasites.

On the other hand, it is most difficult to account for these apparently created structures on an evolutionary basis. The very fact that these organisms can invade a host and go undetected by the immune system implies that certain biocompatibilities were in place before the life cycle was initiated.

Evolutionary Explanations for Apparently Designed Features

A search of the ascocotylid literature failed to produce a satisfactory evolutionary explanation which can account for the complex life cycle and the "design-like" structures employed within this group. One is hard-pressed to synthesize any meaningful evolutionary rationale from this literature, particularly in the field of host behavior modification. Comments like: "a parasite can parlay a small (host) behavioral modification into a large increase in predation" abound (Lafferty and Morris, 1996, p. 1394) (brackets mine).

Stunkard (1946) reviews Odhner's contention that similarities in the reproductive and excretory systems of digenetic trematodes indicate a common origin of all digeneans but he does not elaborate further. Sogandares-Bernal and Lumsden (1964) do not offer a mechanistic solution for the origin or complexity of the ascocotylids, but they do state that a significant and complex behavior of the worm "to remain in the definitive host long enough to produce, but not release a potentially dangerous (to the host) burden of eggs" may be an evolutionary adaptation by the parasite (brackets mine). Cable (1974) does attempt a phylogenetic survey of the trematodes, but does not focus on the digeneans or design features *per se*. Skinner (1975, p. 342) contends (with little argument) that parasites evolve slower than their hosts. He focuses on the intricate features of ascocotylids, saying, "their narrowly defined habitat and high specialization...(makes them) good material for the exploration of evolutionary development...", and "...similarities in the parasite fauna point to close host relationships..." (brackets mine). Overstreet (1978) suggests that the evolutionary relationships of some fishes can be ex-

plained on the basis of the similar types of parasites which infect them. With respect to the complexity of the life cycle, he then states, however, "The more complicated the life cycle and the greater the variation in the stages, the more a cycle can be influenced by the environment" (Overstreet, 1993, p. 127), indicating that possibly the environment molded the life cycle.

In a section of their book describing the staggering complexity of digenetic trematode eyespots, chemosensory papillae and other sensory structures, Schmidt and Roberts (1989, p. 234) exclaim that the "sensory endings (in one larval stage) are strikingly similar to the olfactory receptors of the vertebrate nasal epithelium!" but offer no mechanism of how they came to be that way (brackets mine). This would support a strange phylogeny indeed!

As to why trematode cercariae typically manifest abundantly more sense organs than the supposedly more highly developed adults, they surmise that "(this is) undoubtedly related to the adaptive value of finding a host quickly" (p. 233) (brackets mine). The assumption here is that once the worm adapted to finding a host by using these sense organs, the energy required to maintain the sense organs in the adult became less adaptive than just losing them. This is just one example in a long string of the typically imaginative explanations offered by evolutionists, but then Schmidt and Roberts (1989, p. 240) admit that the complexity of the life cycle has fueled the imagination for a long time:

This alternation of sexual and asexual generations in different hosts is one of the most striking biological phenomena. The variability and complexity of life cycles and ontogeny have stimulated the imaginations of zoologists for more than 100 years, creating a huge amount of literature on the subject. Even so, many mysteries remain, and research on questions of trematode life cycles remains active.

With respect to the wildly different environments this parasite must deal with as it passes from host to host, Schmidt and Roberts (1989, p. 248) state, that they go through a "sequence of totally different habitats in which the various stages must survive, with physiological adjustments that must often be made extremely rapidly." There are wide swings in osmotic pressures from host to host. The chemical nature of the host skin must be detected. They need to penetrate host skin using leukotrienes and prostaglandins (which are very sophisticated proteins) and they must possess a myriad of ways to evade host immunological detection once they are on board. Although the synthesis of these highly specific proteins and enzymes by microscopic parasites is currently unexplainable, evolutionary authors are reluctant to relinquish the supposed materialistic origin:

When one considers that *chance* governs the successful completion of much of the life cycle of any

given parasite, it becomes apparent that the odds against success are nearly overwhelming (Schmidt and Roberts, 1989, p. 12) (*emphasis mine*).

The use of sophisticated macromolecules by these parasites to alter host behavior is also discussed by Lafferty and Morris (1996, p. 1395) who admit that, "We know little about the mechanisms parasites use to alter host behavior, but some evidence exists for sophisticated manipulation of (host) hormones and neurochemicals..." (brackets mine). How this remarkable manipulative ability came about is not discussed.

Schmidt and Roberts (1989, p. 254) emphasize the fact that natural selection provides little help in understanding trematode origins:

Whatever the ancestral digenean, any system of their phylogeny must rationalize the evolution of their complex life cycles in terms of natural selection, a most perplexing task.

The subsequent evolutionary reconstruction is padded with phrases like, 'most authorities today believe', 'this may imply', 'it is not difficult to imagine', 'it may be assumed', 'was probably', 'it is likely that', and 'less difficult to visualize'. It can be seen that the origin of these parasites from an evolutionary point of view is indeed perplexing.

With respect to the supposed evolutionary development of symbiosis and parasitism, McLaughlin and Cain (1983, pp. 189–190) also tender some less than convincing arguments, and frankly state that the "data are scarce". They reference just one laboratory study in which a bacterium and an amoeba established a mutualistic relationship after 100 generations in a controlled laboratory environment. These authors offer four general principles for the origin of symbiosis and admit that:

Naturally, the...model is speculative...

1) Symbioses originate rapidly and frequently in nature. Partners evolve rapidly under the pressures of adapting to the symbiotic relationship. Once a complete, free-living life cycle is impossible for one of the partners, it is committed to the evolutionary progression described.

2) One partner, the host...eventually gains control of the relationship after it becomes obligatory to the other partner, the symbiont.

3) The evolutionary progress is unidirectional; the symbiont often becomes less pathogenic, then non-parasitic, then actually beneficial to the host (if this is possible; if the symbiont has nothing to offer, then it simply becomes extinct).

4) Eventually, the desirable features of the symbiont which can be incorporated by the host are so incorporated. The symbiont becomes either extinct or a diminishing part of the host.

To their credit, the authors are candid about the lack of experimental support for their logic. The problem with

this kind of evolutionary scenario is that generous anthropomorphisms are ascribed to microscopic creatures which can in no way be self-aware. They cannot be aware of the concepts of symbiosis, parasitism, "interesting ploys", "desirable features", "nothing to offer", "selective advantage", etc.—all of which are teleological value judgments which are constantly and readily made. How, indeed, can a parasite "know" what is in its "best interest" from an evolutionary (or any) point of view? Perhaps these authors only mean that these seemingly directed behaviors and structures really occur as a result of natural selection in gene pools, but if that is the case, they do not say so.

Further, the whole idea that a microscopic trematode or other parasite can "guide" its intermediate host to the actual definitive host by "scheming" to alter its behavior via an evolutionary "strategy" is absurd. Carney (1969) discusses the alteration of formicine ant behavior by the lancet fluke trematode (*Dicrocoelium dendriticum*). He writes about this and the liver fluke (*Brachylecithum mosquensis*) which "ensure" their own predation by the herbivorous sheep which serves as the definitive host. These trematodes evidently cause the ant to climb to the tips of grass during the period when sheep graze. With no supporting material, Carney states:

Both flukes have parallelly evolved the ability to alter their intermediate host's behavior such that their own chance of survival is enhanced... Bizarre adaptations to parasitism such as these are one of the most interesting aspects of biology, although often the least known, and indicate a long association between these flukes and their respective hymenopteran hosts (p. 610).

Curio (1988) comments on this as well, stating:

To manipulate hosts behavior patterns seems to ask a lot in evolutionary novelties. However, the brainworm when inducing an ant to cling to the top of plants capitalizes on an apparently ancient behavior... the parasite needed "merely" to reactivate a hidden potential of the ant (p. 151).

Moore (1984) surveys several parasites, particularly in the acanthocephalans (spiny headed worms), which are known to alter intermediate host behavior, and he laments:

...the parasites do not induce novel behavior patterns but merely elicit existing patterns at disastrously inappropriate times. Nevertheless, this is quite a feat, and a general physiological explanation of how an acanthocephalan accomplishes it while floating in the body cavity of the host has yet to be found. The realization that parasites can change host behavior has intriguing implications. Biologists observing certain animals in the field must now take into account the possibility that the observed behavior may have been 'rigged' (p. 115).

Moore, however, does not elaborate on who or what may have done the 'rigging'. In a discussion of host castration by parasites, Hurd (1990, p. 274) writes:

Baudoin (1974), considered parasitic castration in the wider sense, outlined above as an evolutionary strategy, and concluded that a parasite-induced manipulation of host resources away from reproduction may produce increased host survival, thus leading to increased parasite fitness as a result of an improved environment.

In this case it is assumed either that the parasite has "understood" what host resources are and has "devised" a "strategy" to ensure its own fitness, or that chance, natural selection, and mutation caused it.

Aeby (1991) discusses trematodes which encyst in coral polyps as an intermediate stage, changing the polyp appearance and behavior. These trematodes later mature in the definitive host, a coral-eating fish attracted by these very changes.

In the discussion, she writes:

One might question why fish would evolve to feed on infected polyps... I can only speculate about this, but there are several hypothetical explanations... The parasite residing in the fish may have adopted the 'prudent parasite' strategy (Holmes 1983) in which the parasite produces minimal damage to the host (p. 267).

The fact that a parasite induces minimal damage on its fish host hardly seems a compelling reason for a fish to begin feeding on infected polyps in the first place!

Lafferty and Morris (1996, p. 1390) state, "Three main lines of evidence currently support the hypothesis that behavior modification is a parasite strategy evolved to increase transmission..." The authors then go on to point out that the very fact that increased predation by the definitive host is occurring in conjunction with parasitism is evidence enough that such a "strategy" has evolved. One clue to an evolutionary origin for these parasites would be the discovery of a free-living variety or finding a parasitic trematode that completed all stages of the life cycle in one host. There is, however, only one example in the literature of all three stages of this life cycle occurring in one host (Barger and Esch, 2000), but there are no free-living forms. A snail is required as a first intermediate host, followed by a fish or frog, and finally a piscivorous bird or mammal. All digenetic heterophyid trematodes are endoparasitic and obligated to these hosts. Why would a parasite initially become completely dependent upon a host for its very survival? How could such a relationship develop over time from a free-living state to a parasitic state? Why would an *Ascocotyle* tie itself to such a risky developmental route, where not one, but three hosts are required?

Overstreet (1978) classifies all organisms which live together as symbionts. He states that a symbiont becomes a

parasite, "when (it) depends entirely upon a host, occasionally harming it..." (p. 2). Commensals live together and "eat from the same table", and mutualism occurs when "...both parties benefit and both metabolically depend on each other" (Overstreet 1978, pp. 2-4; 1993). There is no doubt that an *Ascocotyle* is a parasite and a commensal. Quite possibly it even has a metabolic dependence upon one or more of its hosts to dissolve its cysts. Some question remains as to whether the *Ascocotyle* worm is involved in a mutualistic relationship in which it actually benefits its host. All members of this genus have an oral coronet of large spines at the adult stage, some having two rows, some having one row, etc. (Armitage 1997a). Of what purpose are these spines? The adult worm appears to lodge in the intestinal mucosal crypts of the definitive host, but does not penetrate the mucosal layer (Font, Overstreet and Heard, 1984; Font, Heard and Overstreet, 1984). Worms hold on in a cup-shaped fashion, over the host villi, by using both the acetabulum and the oral sucker. Yet no pathology to the villi is observed so the oral spines are possibly not used as holdfasts. But of what value are two rows of spines rather than one, or of one additional incomplete row in preference to a complete one? Why is a single incomplete row never observed? The tegument of these worms is entirely covered with a carpet of fine body spines which certainly must aid in anchoring the parasite and resisting host peristalsis.

In experiments conducted with cercaria of *A. mcintoshii* Price, Leigh (1974) discovered that cercarial penetration glands are HCl-sensitive and fully evert in weak solutions of HCl. Of what purpose is a set of penetration glands that are activated only in the presence of HCl, glands that are required for entry into host tissues, unless the parasite in question "anticipates" the gastric juices of the fish which swallows it as the second intermediate host? Could a trial and error method account for this elegant penetration gland? This biochemical functional system seems to fall within Behe's (1996) category of "irreducible complexity." If the sensitivity to HCl were removed, would the parasite fail to penetrate the host tissue? To bequeath this biocompatibility to the ancient processes of time and chance strains one's scientific credibility to the breaking point. One of the most compelling arguments for design within this *Ascocotyle* group comes from the structure of the metacercarial cyst, which is HCl resistant, and yet, temperature, pH and trypsin sensitive (Stein, 1968). Without a temperature of 37° C, a solution adjusted to pH 7.5, and the presence of trypsin, the cyst will not dissolve. Only with this combination can the parasite, encased within its miniature ark, successfully pass the definitive host stomach and dissolve only within the somewhat protective confines of the intestine, which is perfectly matched to its required conditions. Schmidt and Roberts (1989, p. 248) observe, "This combination of conditions is not likely to be present

anywhere but in the intestine of a homoiothermic vertebrate...".

The evolutionary literature has failed to supply us with a proper explanation for how these "design-like" features may have come about by the chance, random processes of evolutionary descent.

Intelligent Design Explanations

The questions which confront us have to do with the relationships, behaviors and specialized structures observed in this parasite — all of which appear to have been designed (Armitage, 1998). Such designs exhibit irreducible complexity as observed by Behe (1996) for the chemical basis of human vision and blood clotting. Behe's conclusion is that a gradualistic, Darwinian mechanism could never have produced these features:

The impotence of Darwinian theory in accounting for the molecular basis of life is evident not only from the analysis in this book, but also from the complete absence in the professional scientific literature of any detailed models by which complex biochemical systems could have been produced...the scientific community is paralyzed. No one at Harvard University, no one at the National Institutes of Health, no member of the National Academy of Sciences, no Nobel prize winner—no one at all can give a detailed account of how the cilium, or vision, or blood clotting, or any complex biochemical process might have developed in a Darwinian fashion (p. 187).

And:

There is an elephant in the roomful of scientists who are trying to explain the development of life. The elephant is labeled 'intelligent design.' To a person who does not feel obligated to restrict his search to unintelligent causes, the straightforward conclusion is that many biochemical systems were designed. They were designed not by the laws of nature, not by chance and necessity; rather they were *planned*. (p.193) (emphasis in the original).

Ascocotylids are able to rapidly manufacture macromolecules necessary to render osmotic potentials harmless. They can synthesize host penetration macromolecules used for swiftly and painlessly entering their intermediate hosts. They also produce the macromolecules which will envelop them with a immune-transparent cyst that will not dissolve in HCl but which will come apart readily in a warm, pH adjusted, environment, bathed in trypsin and bile salts. All these characters demand planning just as much as does Behe's blood clotting mechanism. But the question remains of whether or not a loving God would plan invaders such as these. Were these organisms designed from the start to perform functions they no

longer perform? Answers to these questions may vary but we can be sure that a loving God did not intend the rampant parasitism we observe today.

The only acceptable alternative to the evolution explanation is that these complex life cycles and "design-like" structures were planned by the Creator, at the point in history when He designed all of the other living organisms. Why and how some symbionts have today become pathogenic is open for speculation, but in a creation scenario, pathobiology must certainly be related somehow to the Fall of Adam and the subsequent Curse (Genesis 1:31; 3:18).

Delving Deeper into Trematode Biology: Microtechnique

In an effort to explain the basis of this and other studies, in which TEM has been applied to the cyst walls of trematode worms, a primer on the preparation of biological material is presented in the appendix. The appendix and the illustrations will also serve to orient the reader to the field of microtechnique and to show contrasting features in *Ascocotyle* cysts.

The Ultrastructure of Metacercarial Cyst Walls

At one time researchers believed that the thick-walled metacercarial cyst of trematodes encysted in various hosts was a direct response by the host to the presence of the parasite within tissues (Sogandares-Bernal and Lumsden, 1964). It now is known however, that cyst walls are produced by secretions from the tegument of the metacercaria and may even be used to delineate differing species based upon its unique structure (Stein and Lumsden, 1971b; Stein and Basch, 1977). But certain other authors have not agreed that this is a species characteristic (Huffman, 1968; Wittrock et al., 1991; Walker and Wittrock, 1992). The extent of host response to the presence of cysts varies considerably. The typical host response is the production of a fibrous collagen capsule surrounding the cyst, along with associated host fibroblasts, but there is little or no host immune response (Lumsden, 1968; Stein and Lumsden, 1971a, b; Mitchell, 1974; Higgins et al., 1977; Stein and Basch, 1977; Gulka and Fried, 1979; So and Wittrock, 1982; Galaktionov et al., 1997).

The variation in layers of cyst walls within the ascocotylids is seen in the following examples. *Ascocotyle pachycystis* (Figure 1), produces a four-layered cyst up to 35 micrometers in thickness (Stein and Lumsden, 1971b) with two major, bilayered lamellae. *A. chandleri* (not shown) exhibits a 15 micrometer-thick cyst with two layers (Lumsden, 1968). *A. leighi* (Figure 2), was shown to have a 10 to 11 micrometer thick cyst which also has two layers

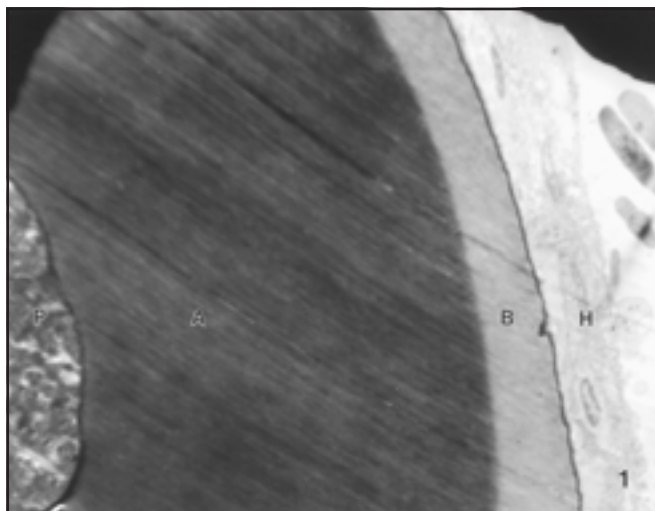


Figure 1. *Ascocotyle pachycystis* in *Cyprinodon* heart, (2,000X). This figure shows a cross section of a fluke parasite (*Ascocotyle*) cyst, growing in the heart of a sheepshead minnow (*Cyprinodon*). Note the very thick layers of the cyst which protect the parasite. Legend for figures 1–4: P = parasite tissue, A = cyst wall 1, B = cyst wall 2, H = host tissue).

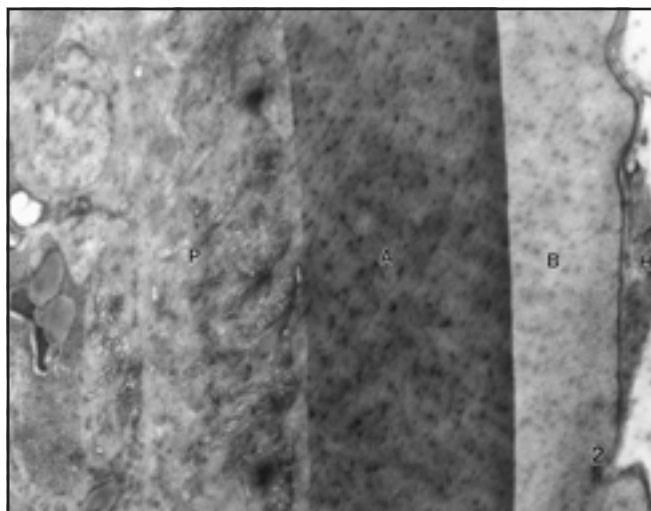


Figure 2. *Ascocotyle leighi* in *Poecilia* heart, (7,000X). This is a cross section of another species of *Ascocotyle* fluke (*A. leighi*) in the heart of the sailfin molly (*Poecilia*). The cyst in this case is much thinner; yet this parasite, when mature is almost identical in shape to *A. pachycystis*.

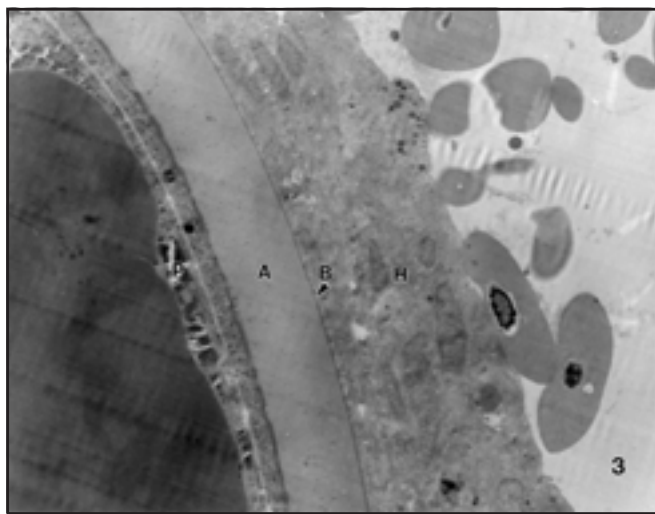


Figure 3. *Ascocotyle tenuicollis* in *Gambusia* heart, (4,000X). Within the heart of *Gambusia*, the mosquitofish, is the cyst of another fluke, *A. tenuicollis*, also shown in cross section. This cyst closely resembles that of *A. leighi*; yet it is a different species found in a different fish host.

(Stein and Lumsden, 1971a). The cysts of *A. tenuicollis* (Figure 3), collected in Mississippi come closer in structure to *A. chandleri* than any other member of this genus because of a three-layered, nine micrometer-thick cyst. *A. sexidigita* has a 16 micrometer-thick, three layered cyst (not shown). *A. (P.) diminuta* has a single cyst wall of 1.5 to 3 micrometers in width (Figure 4), which in every respect resembles the very tegument of the metacercaria it is harboring. The wall is comprised of a spongy matrix of tissue

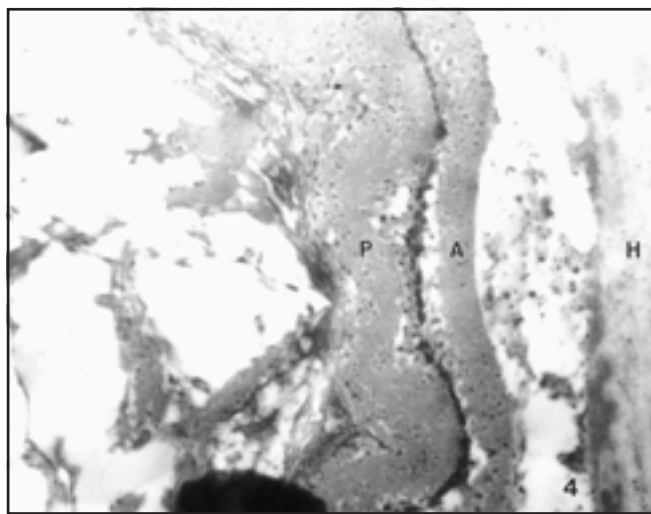


Figure 4. *Ascocotyle (Phagicola) diminuta* in *Fundulus* gill, (8,000X). This fluke, *A. diminuta* is found in the gill tissue of the Killifish (*Fundulus*) and one or two others. Note that the cyst wall and the parasite outer skin are almost identical in appearance.

interspersed with dense nuclei and a very thin granular outer border.

Definitions

Acetabulum: The ventral sucker on a trematode worm.

Amnicolid and Hydrobiid: fresh or brackish water snails belonging to the family Hydrobiidae which are charac-

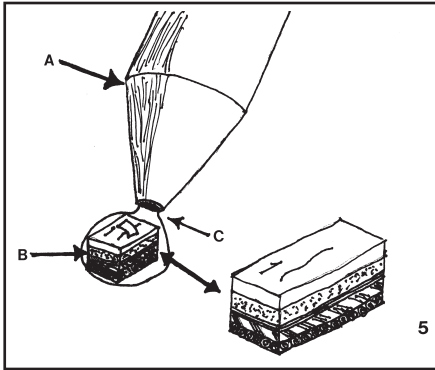


Figure 5. Dissected fish tissue block is chemically processed. Tissues for electron microscopy must first be stabilized in a fixative, such as formalin. This preserves, as close to the living specimen as possible, the ultrastructure of the tissue for the microscope. Legend for figures 5–9: A = dropper, B = tissue block, C = solution, D = capsule, E = polymer, F = thin sections, G = knife, H = grid, I = specimen chamber).

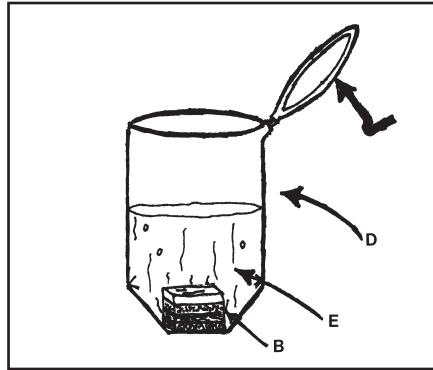


Figure 6. Processed tissue is placed in a liquid polymer. A liquid polymer (plastic) is used to infiltrate the tissues after they have been preserved properly. Once the tissue is thoroughly impregnated with the polymer, it is placed into an oven overnight for hardening. The tissues can then withstand the harshness of the electron microscope.

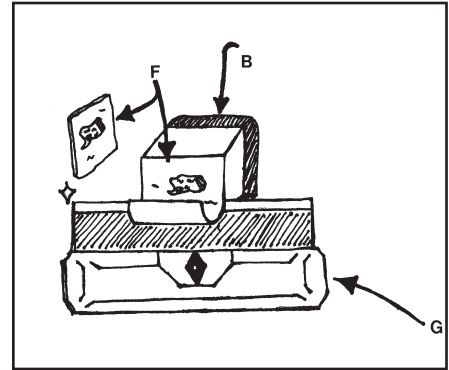


Figure 7. Hardened polymer block with tissue is sectioned into ultra thin sections. Very thin sections of the tissue block are made with a glass or diamond knife of surgical sharpness. These thin sections will go into the microscope.

terized by true gills and opercula, versus pulmonate, or air-breathing, structures.

Cercarial: The last larval stage of trematodes, free swimming, from the first intermediate host, to the second intermediate host, where penetration of that host occurs.

Creationism: The belief that God created all things as described in Genesis.

Cyprinodont: the killifish family of fresh and saltwater minnows.

Digenetic: Subclass Digenea, parasitic worms, a subclass of the Trematoda, having two or more asexual generations, an alternation of hosts, the first almost always a mollusc, and which are endoparasitic in vertebrates such as birds.

Evolutionism: the belief that all life forms arose over millions of years from a common ancestor due to mutations in the genetic code and a stochastic “system” of selection called Natural Selection.

Fecundity: The capacity of an organism to produce offspring.

Hermaphroditic: (often) self-fertilizing organisms which contain both male and female sexual organs.

Heterocercous: “many houses” or complex cycles which require several different hosts to complete.

Heterophyid: having a bifurcated intestinal organ or ceca usually long and truncated.

Metacercaria: the third, or preadult stage of the trematode life cycle, often involving an encystment within the second intermediate host.

Micromorphology: body structures which can only be seen by means of magnification.

Pathogenicity: The causing of disease or toxic response in another organism.

Poeciliid: the topminnow or live-bearer family of fresh and brackish water fishes which hatch young internally and bear live young.

Piscivorous: fish eating vertebrates such as herons, egrets, and raccoons.

Redia: An intermediate larval stage of trematodes that develops asexually within a sporocyst inside the first intermediate host, usually a snail.

SEM: Scanning electron microscope, which images metal coated whole mounts, in magnifications of 100:20,000 diameters using secondary electron capture.

Sensory Papillae: Sophisticated sensory projections from cells or tissues, often containing cilia.

Symbiosis: The intimate and protracted association of individuals of different species.

Tegument: The outer layer or skin of a trematode parasite.

TEM: Transmission electron microscope, which images metal coated thin sections, to magnifications up to 200,000 diameters using primary or direct electron capture.

Trematode: Class Trematoda of helminths which are parasitic flatworms (flukes) mainly in the digestive tract of all classes of vertebrates. These trematodes possess a digestive tract, specialized sensory organs, and muscular sucking disks which serve to attach the fluke to the host.

Appendix

Biological tissues such as *Ascocotyle* cysts must be processed properly in order to be viewed in an electron microscope. First, the tissue of interest must be dissected and chemically processed in fixative, buffers, and alcohols (Lumsden, 1970). Then it must be embedded in a liquid polymer that will harden upon heating (Figures 5–6). Once hardened, the tissues can be thin sectioned on an ultramicrotome (Figure 7: blade and tissue block shown). Finally, tissue sections are transferred to thin metal grids on which they are stained with metal salts and placed into a special chamber in the TEM (Figures 8–9).

Acknowledgments

The author thanks Ronnie Palmer of the Gulf Coast Research Laboratory for specimens, Les Eddington of Azusa Pacific University for technical assistance and for reviewing a preliminary draft of this paper, George Howe for critical comments and support of the project, and Patrick Armitage for illustrations. The author is also indebted to the reviewers for comments.

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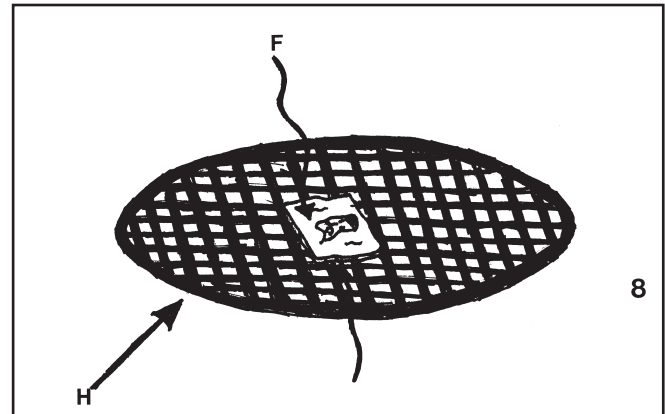


Figure 8. Individual sections are placed onto TEM grids and stained. The grids are metal substrates used to support the thin sections and for handling into and out of the heavy metal staining solutions (lead and uranium salts) as well as the microscope.

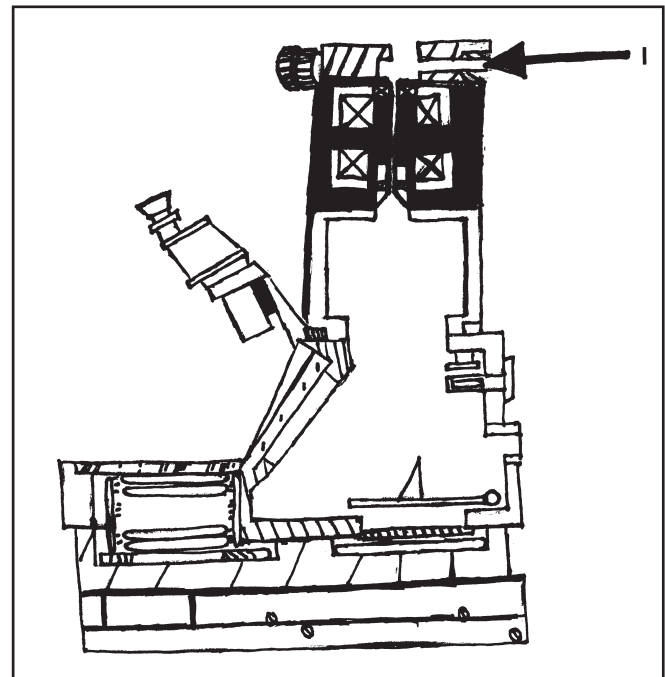


Figure 9. Grids are placed into the TEM for imaging. Once stained, the grids, holding the stained sections are placed into the electron beam. Tissues which took up the metal stain block the passage (transmission) of electrons and appear dark under the microscope.

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Why Abiogenesis Is Impossible

Jerry Bergman*

Abstract

If naturalistic molecules-to-human-life evolution were true, multibillions of links are required to bridge modern humans with the chemicals that once existed in the hypothetical “primitive soup.” This putative soup, assumed by many scientists to have given birth to life over 3.5 billion years ago, was located in the ocean or mud puddles. Others argue that the origin of life could not have been in the sea but rather must have occurred in clay on dry land. Still others conclude that abiogenesis was more likely to have occurred in hot vents. It is

widely recognized that major scientific problems exist with all naturalistic origin of life scenarios. This is made clear in the conclusions of many leading origin-of-life researchers. A major aspect of the abiogenesis question is “What is the minimum number of parts necessary for an autotrophic free living organism to live, and could these parts assemble by naturalistic means?” Research shows that at the lowest level this number is in the multimillions, producing an irreducible level of complexity that cannot be bridged by any known natural means.

Introduction

Abiogenesis is the theory that life can arise spontaneously from non-life molecules under proper conditions. Evidence for a large number of transitional forms to bridge the stages of this process is critical to prove the abiogenesis theory, especially during the early stages of the process. The view of how life originally developed from non-life to an organism capable of independent life and reproduction presented by the mass media is very similar to the following widely publicized account:

Four and a half billion years ago the young planet Earth... was almost completely engulfed by the shallow primordial seas. Powerful winds gathered *random molecules* from the atmosphere. Some were deposited in the seas. Tides and currents swept the *molecules* together. And somewhere in this ancient ocean the miracle of life began... *The first organized form of primitive life was a tiny protozoan [a one-celled animal]*. Millions of protozoa populated the ancient seas. These early organisms were completely self-sufficient in their sea-water world. *They moved about their aquatic environment feeding on bacteria and other organisms...* From these one-celled organisms evolved all life on earth (from the Emmy award winning PBS NOVA film *The Miracle of Life*; quoted in Hanegraaff, 1998, p. 70, emphasis in original).

Science textbook authors Wynn and Wiggins describe the abiogenesis process currently accepted by Darwinists:

Aristotle believed that decaying material could be transformed by the “spontaneous action of Nature” into living animals. His hypothesis was ultimately rejected, but... Aristotle’s hypothesis has been replaced by *another* spontaneous generation hypothesis, one that requires billions of years to go from the molecules of the universe to cells, and then, via random mutation/natural selection, from cells to the variety of organisms living today. This version, which postulates chance happenings eventually leading to the phenomenon of life, is biology’s Theory of Evolution (1997, p. 105).

The question on which this paper focuses is “How much evidence exists for this view of life’s origin?” When Darwinists discuss “missing links” they often imply that relatively few links are missing in what is a rather complete chain which connects the putative chemical precursors of life that is theorized to have existed an estimated 3.5 billion years ago to all life forms existing today. Standen noted a half century ago that the term “missing link” is misleading because it suggests that only *one* link is missing whereas it is more accurate to state that *so many links are missing* that it is not evident whether there was ever a chain (Standen, 1950, p. 106). This assertion now has been well documented by many creationists and others (see Bergman, 1998; Gish, 1995; Lubenow, 1994, 1992; Rodabaugh, 1976; and Moore, 1976).

*Jerry Bergman, Ph.D., Northwest State College, Archbold, OH 43502-9542
Received 24 August 1999; Revised 19 October 1999

Scientists not only have been unable to find a *single undisputed link* that clearly connects *two of the hundreds of major family groups*, but they have not even been able to produce a plausible starting point for their hypothetical evolutionary chain (Shapiro, 1986). The first links—actually the first hundreds of thousands or more links that are required to produce life—still are missing (Behe, 1996, pp. 154–156)! Horgan concluded that if he were a creationist today he would focus on the origin of life because this

...is by far the weakest strut of the chassis of modern biology. The origin of life is a science writer's dream. It abounds with exotic scientists and exotic theories, which are never entirely abandoned or accepted, but merely go in and out of fashion (1996, p. 138).

The major links in the molecules-to-man theory that must be bridged include (a) evolution of simple molecules into complex molecules, (b) evolution of complex molecules into simple organic molecules, (c) evolution of simple organic molecules into complex organic molecules, (d) eventual evolution of complex organic molecules into DNA or similar information storage molecules, and (e) eventually evolution into the first cells. This process requires multimillions of links, all which either are missing or controversial. Scientists even lack plausible just-so stories for most of evolution. Furthermore the parts required to provide life clearly have specifications that rule out most substitutions.

In the entire realm of science no class of molecule is currently known which can remotely compete with proteins. *It seems increasingly unlikely that the abilities of proteins could be realized to the same degree in any other material form.* Proteins are not only unique, but give every impression of being ideally adapted for their role as the universal constructor devices of the cell ... Again, we have an example in which the only feasible candidate for a particular biological role gives every impression of being supremely fit for that role (Denton, 1998, p. 188, emphasis in original).

The logical order in which life developed is hypothesized to include the following basic major stages:

1. Certain simple molecules underwent spontaneous, random chemical reactions until after about half-a-billion years complex organic molecules were produced.
2. Molecules that could replicate eventually were formed (the most common guess is nucleic acid molecules), along with enzymes and nutrient molecules that were surrounded by membraned cells.
3. Cells eventually somehow “learned” how to reproduce by copying a DNA molecule (which contains a complete set of instructions for building a next generation of cells). During the reproduction process,

the mutations changed the DNA code and produced cells that differed from the originals.

4. The variety of cells generated by this process eventually developed the machinery required to do all that was necessary to survive, reproduce, and create the next generation of cells in their likeness. Those cells that were better able to survive became more numerous in the population (adapted from Wynn and Wiggins, 1997, p. 172).

The problem of the early evolution of life and the unfounded optimism of scientists was well put by Dawkins. He concluded that Earth's chemistry was different on our early, lifeless, planet, and that at this time there existed

...no life, no biology, only physics and chemistry, and the details of the Earth's chemistry were very different. Most, though not all, of the informed speculation begins in what has been called the primeval soup, a weak broth of simple organic chemicals in the sea. Nobody knows how it happened but, somehow, without violating the laws of physics and chemistry, a molecule arose that just happened to have the property of self-copying—a replicator. This may seem like a big stroke of luck... Freakish or not, this kind of luck does happen... [and] it had to happen only once... What is more, as far as we know, it may have happened on only one planet out of a billion billion planets in the universe. Of course many people think that it actually happened on lots and lots of planets, but we only have *evidence* that it happened on one planet, after a lapse of half a billion to a billion years. So the sort of lucky event we are looking at *could* be so wildly improbable that the chances of its happening, somewhere in the universe, could be as low as one in a billion billion billion in any one year. If it *did* happen on only one planet, anywhere in the universe, that planet has to be our planet—because here we are talking about it (Dawkins, 1996, pp. 282–283, emphasis in original).

The Evidence for the Early Steps of Evolution

The first step in evolution was the development of simple self-copying molecules consisting of carbon dioxide, water and other inorganic compounds. No one has proven that a simple self-copying molecule can self-generate a compound such as DNA. Nor has anyone been able to create one in a laboratory or even on paper. The hypothetical weak “primeval soup” was not like soups experienced by humans but was highly diluted, likely close to pure water. The process is described as life having originated spontaneously from organic compounds in the oceans of the primitive Earth. The proposal assumes

that primitive oceans contained large quantities of simple organic compounds that reacted to form structures of greater and greater complexity, until there arose a structure that we would call living. In other words, the first living organism developed by means of a series of nonbiological steps, none of which would be highly improbably on the basis of what is known today. This theory, [was] first set forth clearly by A.I. Oparin (1938) ... (Newman, 1967, p. 662).

An astounding number of speculations, models, theories and controversies still surround every aspect of the origin of life problem (Lahav 1999). Although some early scientists proposed that "organic life ... is eternal," most realized it must have come "into existence at a certain period in the past" (Haeckel, 1905, p. 339). It now is acknowledged that the first living organism could not have arisen directly from inorganic matter (water, carbon dioxide, and other inorganic nutrients) even as a result of some extraordinary event. Before the explosive growth of our knowledge of the cell during the last 30 years, it was known that "the simplest bacteria are extremely complex, and the chances of their arising directly from inorganic materials, with no steps in between, are too remote to consider seriously." (Newman, 1967, p. 662). Most major discoveries about cell biology and molecular biology have been made since then.

Search for the Evidence of Earliest Life

Theories abound, but no direct evidence for the beginning of the theoretical evolutionary climb of life up what Richard Dawkins and many evolutionists call "mount improbable" ever has been discovered (Dawkins, 1996). Nor have researchers been able to develop a plausible theory to explain how life *could* evolve from non-life. Many equally implausible theories now exist, most of which are based primarily on speculation. The ancients believed life originated by spontaneous generation from inanimate matter or once living but now dead matter. Aristotle even believed that under the proper conditions putatively "simple" animals such as worms, fleas, mice, and dogs could spring to life spontaneously from moist "Mother Earth."

The spontaneous generation of life theory eventually was proved false by hundreds of research studies such as the 1668 experiment by Italian physician Francesco Redi (1626–1697). In one of the first controlled biological experiments, Redi proved that maggots appeared in meat *only* after flies had deposited their eggs on it (Jenkins-Jones, 1997). Maggots do not spontaneously generate on their own as previously believed by less rigorous experimenters.

Despite Redi's evidence, however, the belief in spontaneous generation of life was so strong in the 1600s that even Redi continued to believe that spontaneous generation could occur *in certain instances*. After the microscope proved the existence of bacteria in 1683, many scientists concluded that these "simple" microscopic organisms must have "spontaneously generated," thereby providing evolution with its beginning. Pasteur and other researchers, though, soon disproved this idea, and the fields of microbiology and biochemistry have since documented quite eloquently the enormous complexity of these compact living creatures (Black, 1998).

Nearly all biologists were convinced by the latter half of the nineteenth century that spontaneous generation of all types of living organisms was impossible (Bergman, 1993a). Now that naturalism dominates science, Darwinists reason that at least one spontaneous generation of life event *must* have occurred in the distant past because no other naturalistic origin-of-life method exists aside from panspermia, which only moves the spontaneous generation of life event elsewhere (Bergman, 1993b). As theism was filtered out of science, spontaneous generation gradually was resurrected in spite of its previous defeat. The solution was to add a large amount of time to the broth:

Aristotle believed that decaying material could be transformed by the "spontaneous action of Nature" into living animals. His hypothesis was ultimately rejected, but, in a way, he might not have been completely wrong. Aristotle's hypothesis has been replaced by *another* spontaneous generation hypothesis, one that requires billions of years to go from the molecules of the universe to cells, and then, *via random mutation/natural selection*, from cells to the variety of organisms living today. This version, which postulates chance happenings eventually leading to the phenomenon of life, is biology's Theory of Evolution (Wynn and Wiggins, 1997, p. 105, emphasis mine).

Although this view now is widely accepted among evolutionists, no one has been able to locate convincing fossil (or other) evidence to support it. The plausibility of abiogenesis has changed greatly in recent years due to research in molecular biology that has revealed exactly how complex life is, and how much evidence exists against the probability of spontaneous generation. In the 1870s and 1880s scientists believed that devising a plausible explanation for the origin of life

would be fairly easy. For one thing, they assumed that life was essentially a rather simple substance called protoplasm that could be easily constructed by combining and recombining simple chemicals such as carbon dioxide, oxygen, and nitrogen (Meyer, 1996, p. 25).

The German evolutionary biologist Ernst Haeckel (1925) even referred to monera cells as simple homogeneous globules of plasm. Haeckel believed that a living cell about as complex as a bowl of Jell-o® could exist, and his origin of life theory reflected this completely erroneous view. He even concluded that cell “autogony” (the term he used to describe living things’ ability to reproduce) was similar to the process of inorganic crystallization. In his words:

The most ancient organisms which arose by spontaneous generation—the original parents of all subsequent organisms—must necessarily be supposed to have been Monera—simple, soft, albuminous lumps of plasma, without structure, without any definite form, and entirely without any hard and formed parts.

About the same time T. H. Huxley proposed a simple two-step method of chemical recombination that he thought could explain the origin of the first living cell. Both Haeckel and Huxley thought that just as salt could be produced spontaneously by mixing powdered sodium metal and heated chlorine gas, a living cell could be produced by mixing the few chemicals they believed were required. Haeckel taught that the basis of life is a substance called “plasm,” and this plasm constitutes

the material foundations of the phenomena of life ... All the other materials that we find in the living organism are products or derivatives of the active plasm: In view of the extraordinary significance which we must assign to the plasm—as the universal vehicle of all the vital phenomena [or as Huxley said “the physical basis of life”]—it is very important to understand clearly all its properties, especially the chemical ones ... In every case where we have with great difficulty succeeded in examining the plasm as far as possible and separating it from the plasma-products, it has the appearance of a colorless, viscous substance, the chief physical property of which is its peculiar thickness and consistency ... Active living protoplasm ... is best compared to a cold jelly or solution of glue (1905 pp. 121,123).

Once the brew was mixed, eons of time allowed spontaneous chemical reactions to produce the simple “protoplasmic substance” that scientists once assumed to be the essence of life (Meyer, 1996, p. 25). As late as 1928, the germ cell still was thought to be relatively simple and

...no one now questions that individual development everywhere consists of progress from a relatively simple to a relatively complex form. Development is not the unfolding of an infolded organism; it is the formation of new structures and functions by combinations and transformations of the relatively simple structures and functions of the germ cells (Conklin, 1928, pp. 63–64).

Cytologists now realize that a living cell contains hundreds of thousands of different complex parts such as various motor proteins that are assembled to produce the most complex “machine” in the Universe—a machine far more complex than the most complex Cray super computer. We now also realize after a century of research that the eukaryote protozoa thought to be as simple as a bowl of gelatin in Darwin’s day actually are enormously more complex than the prokaryote cell. Furthermore, molecular biology has demonstrated that the basic design of the cell is

essentially the same in all living systems on earth from bacteria to mammals... In terms of their basic biochemical design... no living system can be thought of as being primitive or ancestral with respect to any other system, nor is there the slightest empirical hint of an evolutionary sequence among all the incredibly diverse cells on earth (Denton, 1986, p. 250).

This is a major problem for Darwinism because life at the cellular level generally does not reveal a gradual increase in complexity as it ascends the evolutionary ladder from protozoa to humans. The reason that all cells are basically alike is because the basic biochemical requirements and constraints for all life are the same:

A curious similarity underlies the seemingly varied forms of life we see on the earth today: the most central molecular machinery of modern organisms has always been found to be essentially the same. This unity of biochemistry has surely been one of the great discoveries of the past 100 years (Cairns-Smith, 1985, p. 90).

The most critical gap that must be explained is that between life and non-life because

Cells and organisms are very complex... [and] there is a surprising uniformity among living things. We know from DNA sequence analyses that plants and higher animals are closely related, not only to each other, but to relatively simple single-celled organisms such as yeasts. Cells are so similar in their structure and function that many of their proteins can be interchanged from one organism to another. For example, yeast cells share with human cells many of the central molecules that regulate their cell cycle, and several of the human proteins will substitute in the yeast cell for their yeast equivalents! (Alberts, 1992, p. xii).

The *belief* that spontaneous regeneration, while admittedly very rare, is still attractive as illustrated by Sagan and Leonard’s conclusion, “Most scientists agree that life will appear spontaneously in any place where conditions remain sufficiently favorable for a very long time” (1972, p. 9). This claim then is followed by an admission from Sagan and Leonard that raises doubts not only about abiogenesis, but about Darwinism generally, namely, “this

conviction [about the origin of life] is based on inferences and extrapolations." The many problems, inferences, and extrapolations needed to create abiogenesis just-so stories once were candidly admitted by Dawkins:

An origin of life, anywhere, consists of the chance arising of a self-replicating entity. Nowadays, the replicator that matters on Earth is the DNA molecule, but the original replicator probably was not DNA. We don't know what it was. Unlike DNA, the original replicating molecules cannot have relied upon complicated machinery to duplicate them. Although, in some sense, they must have been equivalent to "Duplicate me" instructions, the "language" in which the instructions were written was not a highly formalized language such that only a complicated machine could obey them. The original replicator cannot have needed elaborate decoding, as DNA instructions... do today. Self-duplication was an inherent property of the entity's structure just as, say, hardness is an inherent property of a diamond... the original replicators, unlike their later successors the DNA molecules, did not have complicated decoding and instruction-obeying machinery, because complicated machinery is the kind of thing that arises in the world only after many generations of evolution. And evolution does not get started until there are replicators. In the teeth of the so-called "Catch-22 of the origin of life"... the original self-duplicating entities must have been simple enough to arise by the spontaneous accidents of chemistry (1996, p. 285).

The method used in constructing these hypothetical replicators is not stated, nor has it ever been demonstrated to exist either in the laboratory or on paper. The difficulties of terrestrial abiogenesis are so great that some evolutionists have hypothesized that life could not have originated on earth but must have been transported here from another planet via star dust, meteors, comets, or spaceships (Bergman, 1993b)! As noted above, panspermia does not solve the origin of life problem though, but instead moves the abiogenesis problem elsewhere. Furthermore, since so far as we know no living organism can survive very long in space because of cosmic rays and other radiation, "this theory is ... highly dubious, although it has not been disproved; also, it does not answer the question of where or how life did originate" (Newman, 1967, p. 662).

Darwin evidentially recognized how serious the abiogenesis problem was for his theory, and once even conceded that all existing terrestrial life must have descended from some primitive life form that was called into life "by the Creator" (1900, p. 316). But to admit, as Darwin did, the possibility of *one or a few creations is to open the door to the possibility of many or even thousands!* If God made one animal type, He also could have made two or many thousands of different types. No contemporary hypothesis today

has provided a viable explanation as to how the abiogenesis origin of life could occur by naturalistic means. The problems are so serious that the majority of evolutionists today tend to shun the whole subject of abiogenesis.

History of Modern Abiogenesis Research

The "warm soup" theory, still the most widely held theory of abiogenesis among evolutionists, was developed most extensively by Russian scientist A.I. Oparin in the 1920s. The theory held that life evolved when organic molecules rained into the primitive oceans from an atmospheric soup of chemicals interacting with solar energy. Later Haldane (1928), Bernal (1947) and Urey (1952) published their research to try to support this model, all with little success. Then came what some felt was a breakthrough by Harold Urey and his graduate student Stanley Miller in the early 1950s.

The most famous origin of life experiment was completed in 1953 by Stanley Miller at the University of Chicago. At the time Miller was a 23-year-old graduate student working under Urey who was trying to recreate in his laboratory the conditions then thought to have preceded the origin of life. The Miller/Urey experiments involved filling a sealed glass apparatus with methane, ammonia, hydrogen gases (representing what they thought composed the early atmosphere) and water vapor (to simulate the ocean). Next, they used a spark-discharge device to strike the gases in the flask with simulated lightning while a heating coil kept the water boiling. Within a few days, the water and gas mix produced a reddish stain on the sides of the flask. After analyzing the substances that had been formed, they found several types of amino acids. Eventually Miller and other scientists were able to produce 10 of the 20 amino acids required for life by techniques similar to the original Miller/Urey experiments.

Urey and Miller assumed that the results were significant because some of the organic compounds produced were the building blocks of proteins, the basic structure of all life (Horgan, 1996, p. 130). Although widely heralded by the press as "proving" the origin of life could have occurred on the early earth under natural conditions without intelligence, the experiment actually provided compelling evidence for exactly the opposite conclusion. For example, equal quantities of both right- and left-handed organic molecules always were produced by the Urey/Miller procedure. In real life, nearly all amino acids found in proteins are left handed, almost all polymers of carbohydrates are right handed, and the opposite type can be toxic to the cell. In a summary the famous Urey/Miller origin-of-life experiment, Horgan concluded:

Miller's results seem to provide stunning evidence that life could arise from what the British

chemist J.B.S. Haldane had called the “primordial soup.” Pundits speculated that scientists, like Mary Shelley’s Dr. Frankenstein, would shortly conjure up living organisms in their laboratories and thereby demonstrate in detail how genesis unfolded. It hasn’t worked out that way. In fact, almost 40 years after his original experiment, Miller told me that solving the riddle of the origin of life had turned out to be more difficult than he or anyone else had envisioned (1996, p. 138).

The reasons why creating life in a test tube turned out to be far more difficult than Miller or anyone else expected are numerous and include the fact that scientists now know that the complexity of life is far greater than Miller or anyone else in pre-DNA revolution 1953 ever imagined. Actually life is far more complex and contains far more information than anyone in the 1980s believed possible. In an interview with Miller, now considered one of “the most diligent and respected origin-of-life researchers,” Horgan reported that after Miller completed his 1953 experiment, he

...dedicated himself to the search for the secret of life. He developed a reputation as both a rigorous experimentalist and a bit of a curmudgeon, someone who is quick to criticize what he feels is shoddy work....he fretted that his field still had a reputation as a fringe discipline, not worthy of serious pursuit.... Miller seemed unimpressed with any of the current proposals on the origin of life, referring to them as “nonsense” or “paper chemistry.” He was so contemptuous of some hypotheses that, when I asked his opinion of them, he merely shook his head, sighed deeply, and snickered—as if overcome by the folly of humanity. Stuart Kauffman’s theory of autocatalysis fell into this category. “Running equations through a computer does not constitute an experiment,” Miller sniffed. Miller acknowledged that scientists may never know precisely where and when life emerged. “We’re trying to discuss a historical event, which is very different from the usual kind of science, and so criteria and methods are very different,” he remarked... (Horgan, 1996, p. 139).

The major problem of Miller’s experiment is well put by Davies,

Making the building blocks of life is easy—amino acids have been found in meteorites and even in outer space. But just as bricks alone don’t make a house, so it takes more than a random collection of amino acids to make life. Like house bricks, the building blocks of life have to be assembled in a very specific and exceedingly elaborate way before they have the desired function (Davies, 1999, p. 28).

We now realize that the Urey/Miller experiments did not produce evidence for abiogenesis because, although

amino acids are the building blocks of life, the key to life is information (Pigliucci, 1999; Dembski, 1998). Natural objects in forms resembling the English alphabet (circles, straight lines and similar) abound in nature, but this does not help us to understand the origin of information (such as that in Shakespeare’s plays) because this task requires intelligence both to create the information (the play) and then to translate that information into symbols. What must be explained is the *source of the information* in the text (the words and ideas), not the existence of circles and straight lines. Likewise, the information contained in the genome must be explained (Dembski, 1998). Complicating the situation is the fact that

research has since drawn Miller’s hypothetical atmosphere into question, causing many scientists to doubt the relevance of his findings. Recently, scientists have focused on an even more exotic amino acid source: meteorites. Chyba is one of several researchers who have evidence that extraterrestrial amino acids may have hitched a ride to Earth on far flung space rocks (Simpson, 1999, p. 26).

Yet another difficulty is, even if the source of the amino acids and the many other compounds needed for life could be explained, it still must be explained as to how these many diverse elements became aggregated in the same area and then properly assembled themselves. This problem is a major stumbling block to any theory of abiogenesis:

...no one has ever satisfactorily explained how the widely distributed ingredients linked up into proteins. Presumed conditions of primordial Earth would have driven the amino acids toward lonely isolation. That’s one of the strongest reasons that Wächtershäuser, Morowitz, and other hydrothermal vent theorists want to move the kitchen [that cooked life] to the ocean floor. If the process starts down deep at discrete vents, they say, it can build amino acids—and link them up—right there (Simpson, 1999, p. 26).

Several recent discoveries have led some scientists to conclude that life may have arisen in submarine vents whose temperatures approach 350° C. Unfortunately for both warm pond and hydrothermal vent theorists, heat may be the downfall of their theory.

Heat and Biochemical Degradation Problems

Charles Darwin’s hypothesis that life first originated on earth in a warm little pond somewhere on a primitive earth has been used widely by most nontheists for over a century in attempts to explain the origin of life. Several reasons exist for favoring a warm environment for the start of life on

earth. A major reason is that the putative oldest known organisms on earth are alleged to be hyperthermophiles that require temperatures between 80° and 110° C in order to thrive (Levy and Miller, 1998). In addition some atmospheric models have concluded that the surface temperature of the early earth was much higher than it is today.

A major drawback of the “warm little pond” origin-of-life theory is its apparent ability to produce sufficient concentrations of the many complex compounds required to construct the first living organisms. These compounds must be sufficiently stable to insure that the balance between synthesis and degradation favors synthesis (Levy and Miller, 1998). The warm pond and hot vent theories also have been seriously disputed by experimental research that has found the half-lives of many critically important compounds needed for life to be far “too short to allow for the adequate accumulation of these compounds” (Levy and Miller, 1998, p. 7933). Furthermore, research has documented that “unless the origin of life took place extremely rapidly (in less than 100 years), we conclude that a high temperature origin of life... cannot involve adenine, uracil, guanine or cytosine” because these compounds break down far too fast in a warm environment. In a hydrothermal environment, most of these compounds could neither form in the first place, nor exist for a significant amount of time (Levy and Miller, p. 7933).

As Levy and Miller explain, “the rapid rates of hydrolysis of the nucleotide bases A,U,G and T at temperatures much above 0° Celsius would present a major problem in the accumulation of these presumed essential components on the early earth” (p. 7933). For this reason, Levy and Miller postulated that either a two-letter code or an alternative base pair was used instead. This requires the development of an entirely *different kind* of life, a conclusion that is not only highly speculative, but likely impossible because no other known compounds have the required properties for life that adenine, uracil, guanine and cytosine possess. Furthermore, this would require life to evolve based on a hypothetical two-letter code or alternative base pair system. Then life would have to *re-evolve* into a radically new form based on the present code, a change that appears to be impossible according to our current understanding of molecular biology.

Furthermore, the authors found that, given the minimal time perceived to be necessary for evolution to occur, cytosine is unstable *even at temperatures as cold as 0° C*. Without cytosine neither DNA or RNA can exist. One of the main problems with Miller’s theory is that his experimental methodology has not been able to produce much more than a few amino acids which actually lend little or no insight into possible mechanisms of abiogenesis.

Even the simpler molecules are produced only in small amounts in realistic experiments simulating

possible primitive earth conditions. What is worse, these molecules are generally minor constituents of tars: It remains problematical how they could have been separated and purified through geochemical processes whose normal effects are to make organic mixtures more and more of a jumble. With somewhat more complex molecules these difficulties rapidly increase. In particular a purely geochemical origin of nucleotides (the subunits of DNA and RNA) presents great difficulties. In any case, nucleotides have not yet been produced in realistic experiments of the kind Miller did. (Cairns-Smith, 1985, p. 90).

Postulating alternative codes for an origin-of-life event at temperatures close to the freezing point of water is a rationalization designed to overcome what appears to be a set of insurmountable problems for the abiogenesis theory. Given these problems, why do so many biologists believe that life on earth originated by spontaneous generation under favorable conditions? Yockey concludes that although Miller’s paradigm was at one time

worth consideration, now the entire effort in the primeval soup paradigm is self-deception based on the ideology of its champions... The history of science shows that a paradigm, once it has achieved the status of acceptance (and is incorporated in textbooks) and regardless of its failures, is declared invalid only when a new paradigm is available to replace it ... It is a characteristic of the true believer in religion, philosophy and ideology that he must have a set of beliefs, come what may... There is no reason that this should be different in the research on the origin of life ...Belief in a primeval soup on the grounds that no other paradigm is available is an example of the logical *fallacy of the false alternative*... (Yockey, 1992, p. 336 emphasis in original).

The many problems with the warm soup model have motivated the development of many other abiogenesis models. One is the cold temperature model that is gaining in acceptance as the flaws of the hot model become more obvious. As Vogel notes, many researchers still

argue that the first cells arose in the scalding waters of hot springs or geothermal vents, while a small but prominent band of holdouts insists on cool pools or even cold oceans. With no fossils to go by, the argument has circled a variety of indirect clues ... But now ... comes good news from the cold camp: Evidence from the genes of living organisms suggests that the cell that gave rise to all of today’s life-forms was ill-suited for extremely hot conditions (Vogel, 1999, p. 155).

Based on a geochemical assessment, Thaxton, Bradley, and Olsen (1984 p. 66) concluded that in the atmosphere

the “many destructive interactions would have so vastly diminished, if not altogether consumed, essential precursor chemicals, that chemical evolution rates would have been negligible” in the various water basins on the primitive earth. They concluded that the “soup” would have been far too diluted for direct polymerization to occur. Even local ponds where some concentrating of soup ingredients may have occurred would have met with the same problem.

Furthermore, no geological evidence indicates an organic soup, even a small organic pond, ever existed on this planet. It is becoming clear that however life began on earth, the usually conceived notion that life emerged from an oceanic soup of organic chemicals is a most implausible hypothesis. We may therefore with fairness call this scenario “the myth of the prebiotic soup” (Thaxton, Bradley, and Olsen, 1984, p. 66).

It also is theorized that life must have begun in clay because the “clay-life” explanation explains several problems not explained by the “primordial soup” theory. Graham Cairns-Smith of the University of Scotland first proposed the clay-life theory about 40 years ago, and many scientists have since come to believe that life on earth must have begun from clay rather than in the the warm little pond as proposed by Darwin. The clay-life theory holds that an accumulation of chemicals produced in clay by the sun eventually led to the hypothetical self-replicating molecules that evolved into cells and then eventually into all life forms on earth today.

The theory argues that only clay has the two essential properties necessary for life: the capacity to both store and transfer energy. Furthermore, because some clay components have the ability to act as catalysts, clay is capable of some of the same lifelike attributes as those exhibited by enzymes. Additionally the mineral structure of certain clays are almost as intricate as some organic molecules. However, the clay theory suffered from its own set of problems, and as a result has been discarded by most theorists. At the very least, the Stanley Miller experiments proved that amino acids can be formed under certain conditions. The clay theory has yet to achieve even this much. As a result, Miller’s experiments continue to be cited because no other viable source exists for the production of amino acids. Now, the hot thermal vent theory is being discussed once again by many as an alternative although, as noted above, it too suffers from potentially lethal problems.

What is Needed to Produce Life

Naturalism requires enormously long periods of time to allow non-living matter to evolve into the hypothetical speck of viable protoplasm needed to start the process that results in life. Even *more* time is needed to evolve the protoplasm

into the enormous variety of highly organized complex life forms that have been found in Cambrian rocks. Neo-Darwinism suggests that life originated over 3.5 billion years ago, yet a rich fossil record for less than roughly 600 million years commonly is claimed. Consequently, almost all the record is missing, and evidence for the most critical two billion years of evolution is sparse at best with what little actually exists being highly equivocal.

A major issue then, in abiogenesis is “what is the *minimum* number of possible parts that allows something to live?” The number of parts needed is large, but how large is difficult to determine. In order to be considered “alive,” an organism must possess the ability to metabolize and assimilate food, to respire, to grow, to reproduce and to respond to stimuli (a trait known as irritability). These criteria were developed by biologists who were trying to understand the process we call life. Although these criteria are not perfect, they are useful in spite of cases that seem to contradict our definition. A mule, for instance, cannot usually reproduce but clearly is alive, and a crystal can “reproduce” but clearly is not alive. One attempt by an evolutionist to determine what is needed in order to self-replicate produced the following conclusions:

If we ditch the selfish-replicator illusion, and accept that the only known biological entity capable of autonomous replication is the cell (full of cooperating genes and proteins, etc.)... DNA replication is so error-prone that it needs the prior existence of protein enzymes to improve the copying fidelity of a gene-size piece of DNA. “Catch-22,” say Maynard Smith and Szathmary. So, wheel on RNA with its now recognized properties of carrying both informational and enzymatic activity, leading the authors to state: “In essence, the first RNA molecules did not need a protein polymerase to replicate them; they replicated themselves.” Is this a fact or a hope? I would have thought it relevant to point out for ‘biologists in general’ that not one self-replicating RNA has emerged to date from quadrillions (10^{24}) of artificially synthesized, random RNA sequences (Dover, 1999, p. 218).

The cell, then appears to be the only biological entity that self-reproduces and simultaneously possesses the other traits required for life. The question then becomes “What is the *simplest* cell that can exist?”

Many bacteria and all viruses possess less complexity than required for an organism normally defined as “living,” and for this reason must live as parasites which require the existence of complex cells in order to reproduce. For this reason Trefil noted that the question of where viruses come from is an “enduring mystery” in evolution. Viruses usually are much smaller than parasitic bacteria and are not considered alive because they must rely on their host even more than bacteria do. Viruses consist primarily

of a coat of proteins surrounding DNA or RNA that contains a handful of genes, and since they do not

... reproduce in the normal way, it's hard to see how they could have gotten started. One theory: they are parasites who, over a long period of time, have lost the ability to reproduce independently... Viruses are among the smallest of "living" things. A typical virus, like the one that causes ordinary influenza, may be no more than a thousand atoms across. This is in comparison with cells which may be hundreds or even thousands of times that size. Its small size is one reason that it is so easy for a virus to spread from one host to another—it's hard to filter out anything that small (Trefil, 1992, p. 91).

In order to reproduce, a virus's genes must invade a living cell and take control of its much larger DNA. A bacterium is 400 times greater in size than the smallest known virus, while a typical human cell averages 200 times larger than the smallest known bacterium. The QB virus is only 24 nanometers long, contains only 3 genes and is almost 20 times smaller than *Escherichia coli*, billions of which inhabit the human intestines. *E. coli* is 1,000 nanometers long compared to a typical human cell that is about 10,000 nanometers long (1 nanometer equals 1 billionth of a meter, or about 1/25-millionths of an inch) and contains an estimated 100,000 genes. Researchers have detected microbes in human and bovine blood that are only 2-millionths of an inch in diameter, but these organisms cannot live on their own because they need more than simple inorganic, or common inorganic molecules to survive.

Since parasites lack many of the genes (and other biological machinery) required to survive on their own, in order to grow and reproduce they must obtain the nutrients and other services they require from the organisms that serve as their hosts. Independent free-living creatures such as people, mice and roses are far more complex than organisms like parasites and viruses that are dependent on these complex free-living organisms. Abiogenesis theory requires that the first life forms consisted of free-living autotrophs (i.e. organisms that are able to manufacture their own food) since the complex life forms needed to sustain heterotrophs (organisms that cannot manufacture their own food) did not exist until later.

Most extremely small organisms existing today are dependent on other, more complex organisms. Some organisms can overcome their lack of size and genes by borrowing genes from their hosts or by gorging on a rich broth of organic chemicals like blood. Some microbes live in colonies in which different members provide different services. Unless one postulates the unlikely scenario of the simultaneous spontaneous generation of *many different organisms*, one has to demonstrate the evolution of an organism that can survive on its own, or with others like itself, as a symbiont or cannibal. Consequently, the putative first

life forms must have been much more complex than most examples of "simple" life known to exist today.

The simplest microorganisms, Chlamydia and Rickettsia, are the smallest living things known, but also are both parasites and thus too simple to be the first life. Only a few hundred atoms across, they are smaller than the largest virus and have about half as much DNA as do other species of bacteria. Although they are about as small as possible and still be living, these two forms of life still possess the millions of atomic parts necessary to carry out the biochemical functions required for life, yet they still are too simple to live on their own and thus must use the cellular machinery of a host in order to live (Trefil, 1992, p. 28). Many of the smaller bacteria are not free living, but are parasite like viruses that can live only with the help of more complex organisms (Galtier et al., 1999).

The gap between non-life and the simplest cell is illustrated by what is believed to be the organism with the smallest known genome of any free living organism *Mycoplasma genitalium* (Fraser et al., 1995). *M. genitalium* is 200 nanometers long and contains only 482 genes or over 0.5 million base pairs which compares to 4,253 genes for *E. coli* (about 4,720,000 nucleotide base pairs), with each gene producing an enormously complex protein machine (Fraser et al., 1995). *M. genitalium* also must live off other life because they are too simple to live on their own. They invade reproductive tract cells and live as parasites on organelles that are far larger and more complicated but which must *first* exist for the survival of parasitic organisms to be possible. The first life therefore must be much more complex than *M. genitalium* even though it is estimated to manufacture about 600 different proteins. A typical eukaryote cell consists of an estimated 40,000 different protein molecules and is so complex that to acknowledge that the "cells exist at all is a marvel... even the simplest of the living cells is far more fascinating than any human-made object" (Alberts, 1992, pp. xii, xiv).

M. genitalium is one-fifth the size of *E. coli* but four times larger than the putative nanobacteria. Blood nanobacteria are only 50 nanometers long (which is smaller than some viruses), and possess a currently unknown number of genes. When Finnish biologist Olavi Kajander discovered nanobacteria in 1998, he called them a "bizarre new form of life." Nanobacteria now are speculated to resemble primitive life forms which presumably arose in the postulated chemical soup that existed when earth was young. Kajander concluded that nanobacteria may serve as a model for primordial life, and that their modern-day primordial soup is blood. Actually, nanobacteria cannot be the smallest form of life because they evidently are parasites and primordial life must be able to live independently. Like viruses they are not considered alive but are of intense medical interest because they may be one cause of kidney stones (Kajander and Ciftcioglu, 1998). Other re-

searchers think these bacteria are only a degenerate form of larger bacteria.

For these reasons, when researching the minimum requirements needed to live the example of *E. coli* is more realistic. Most bacteria require several thousand genes to carry out the minimum functions necessary for life. Denton notes that even though the tiniest bacterial cells are incredibly small, weighing under 10^{-12} grams, each bacterium is a

veritable micro-miniaturized factory containing thousands of exquisitely designed pieces of intricate molecular machinery, made up altogether of one hundred thousand million atoms, far more complicated than any machine built by man and absolutely without parallel in the non-living world (Denton, 1986, p. 250).

The simplest form of life requires millions of parts at the atomic level, and the higher life forms require trillions. Furthermore, the many macromolecules necessary for life are constructed of even smaller parts called elements. That life requires a certain minimum number of parts is well documented; the only debate now is *how many* millions of functionally integrated parts are necessary. The minimum number may not produce an organism that can survive long enough to effectively reproduce. Schopf notes that simple life without complex repair systems to fix damaged genes and their protein products stand little chance of surviving. When a mutation occurs

cells like those of humans with two copies of each gene can often get by with one healthy version. But a mutation can be deadly if it occurs in an organism with only a single copy of its genes, like many primitive forms of life.... (Schopf, 1999, p. 102)

Therefore, the answer to our original question, "What is the smallest form of nonparasitic life?" probably is an organism close to size and complexity of *E. Coli*, possibly even larger. No answer is currently possible because we have much to learn about what is required for life. As researchers discover new exotic "life" forms thriving in rocks, ice, acid, boiling water and other extreme environments, they are finding the biological world to be much more complex than assumed merely a decade ago. The oceans now are known to be teeming with microscopic cells which form the base of the food chain on which fish and other larger animals depend. It now is estimated that small, free-living aquatic bacteria make up about *one-half* of the entire biomass of the oceans (MacAyeal, 1995).

Many highly complex animals appear very early in the fossil record and many "simple" animals thrive today. The earliest fossils known, which are believed to be those of cyanobacteria, are quite similar structurally and biochemically to bacteria living today. Yet it is claimed they thrived almost as soon as earth formed (Schopf, 1993; Galtier et al., 1999). Estimated at 3.5 billion years old, these earliest

known forms of life are incredibly complex. Furthermore, remarkably diverse types of animals existed very early in earth history and no less than eleven different species have been found so far. A concern Corliss raises is "why after such rapid diversification did these microorganisms remain essentially unchanged for the next 3.465 billion years? Such stasis, common in biology, is puzzling" (1993, p. 2). *E. coli*, as far as we can tell, is the same today as in the fossil record.

Probability Arguments

As Coppedge (1973) notes, even 1) postulating a primordial sea with every single component necessary for life, 2) speeding up the bonding rate so as to form different chemical combinations a trillion times more rapidly than hypothesized to have occurred, 3) allowing for a 4.6 billion-year-old earth and 4) using all atoms on the earth still leaves the probability of a single protein molecule being arranged by chance is 1 in 10,261. Using the lowest estimate made before the discoveries of the past two decades raised the number several fold. Coppedge estimates the probability of 1 in $10^{119,879}$ is necessary to obtain the minimum set of the required estimate of 239 protein molecules for the smallest theoretical life form.

At this rate he estimates it would require $10^{119,831}$ years on the average to obtain a set of these proteins by naturalistic evolution (1973, pp. 110, 114). The number he obtained is $10^{119,831}$ greater than the current estimate for the age of the earth (4.6 billion years). In other words, this event is outside the range of probability. Natural selection cannot occur until an organism exists and is able to reproduce which requires that the first complex life form first exist as a functioning unit.

In spite of the overwhelming empirical and probabilistic evidence that life could not originate by natural processes, evolutionists possess an unwavering belief that some day they will have an answer to how life could spontaneously generate. Nobel laureate Christian de Duve (1995) argues that life is the product of law-driven chemical steps, each one of which must have been highly probable in the right circumstances. This reliance upon an unknown "law" favoring life has been postulated to replace the view that life's origin was a freakish accident unlikely to occur anywhere, is now popular. Chance is now out of favor in part because it has become clear that even the simplest conceivable life form (still much simpler than any actual organism) would have to be so complex that accidental self-assembly would be nothing short of miraculous even in two billion years (Spetner, 1997). Furthermore, natural selection cannot operate until biological reproducing units exist. This hoped for "law," though, has no basis in fact nor does it even have a theoretical basis. It is a nebu-

lous concept which results from a determination to continue the quest for a naturalistic explanation of life. In the words of Horgan:

One day, he [Stanley Miller] vowed, scientists would discover the self-replicating molecule that had triggered the great saga of evolution....[and] the discovery of the first genetic material [will] legitimize Miller's field. "It would take off like a rocket," Miller muttered through clenched teeth. Would such a discovery be immediately self-apparent? Miller nodded. "It will be in the nature of something that will make you say, 'Jesus, there it is. How could you have overlooked this for so long?' And everybody will be totally convinced" (Horgan, 1996, p. 139).

The atheistic world view requires abiogenesis; therefore scientists must try to deal with the probability arguments. The most common approach is similar to the attempt by Stenger, who does not refute the argument but tries to explain it by way analogy:

For example, every human being on Earth is the product of a highly elaborate combination of genes that would be a very unlikely outcome of a random toss. Think of what an unlikely being you are—the result of so many chance encounters between your male and female ancestors. What if your great great great grandmother had not survived that childhood illness? What if your grandfather had been killed by a stray bullet in a war, before he met your grandmother? Despite all those contingencies, you still exist. And if you ask, *after the fact*, what is the probability for your particular set of genes existing, the answer is one hundred percent. Certainty! (1998, p. 9).

The major problem with this argument, as shown by Dembski, is that it is a gross misuse of statistics, one of the most important tools science has ever developed. Although change is involved, intelligence is critically important even in the events Stenger describes. The fallacy of his reasoning can be illustrated by comparing it to a court case using DNA. Stenger's analogy cannot negate the finding that the likelihood is 1 in 100 million that a blood sample found on the victim at the crime is the suspect's. For this reason, it is highly probable that the accused was at the crime scene; the fact that his blood was mixed with the victim's, will no doubt be accepted by the court and an attempt to destroy this conclusion by use of an analogy such as Stenger's will likely be rejected.

Conclusions

It appears that the field of molecular biology will falsify Darwinism. An estimated 100,000 different proteins are used to construct humans alone. Furthermore, one million species are known, and as many as 10 million may ex-

ist. Although many proteins are used in most life forms, as many as *100 million or more protein variations* may exist in all plant and animal life. According to Asimov:

Now, almost each of all the thousands of reactions in the body is catalyzed by a specific enzyme ... a different one in each case ... and every enzyme is a protein, a *different* protein. The human body is not alone in having thousands of different enzymes—so does every other species of creature. Many of the reactions that take place in human cells also happen in the cells of other creatures. Some of the reactions, indeed, are universal, in that they take place in all cells of every type. This means that an enzyme capable of catalyzing a particular reaction may be present in the cells of wolves, octopi, moss, and bacteria, as well as in our own cells. And yet each of these enzymes, capable though it is of catalyzing one particular reaction, is characteristic of its own species. They may all be distinguished from one another. It follows that every species of creature has thousands of enzymes and that all those enzymes may be different. Since there are over a million different species on earth, it may be possible—judging from the enzymes alone—that different proteins exist by the millions! (Asimov, 1962, pp. 27–28).

Even using an unrealistically low estimate of 1,000 steps required to "evolve" the average protein (if this were possible) implies that many *trillions* of links were needed to evolve the proteins that once existed or that exist today. And *not one* clear transitional protein that is morphologically and chemically in between the ancient and modern form of the protein has been convincingly demonstrated. The same problem exists with fats, nucleic acids, carbohydrates and the other compounds that are produced by, and necessary for, life.

Scientists have yet to discover a single molecule that has "learned to make copies of itself" (Simpson, 1999, p. 26). Many scientists seem to be oblivious of this fact because

Articles appearing regularly in scientific journals claim to have generated self-replicating peptides or RNA strands, but they fail to provide a natural source for their compounds or an explanation for what fuels them... this top-down approach... [is like] a caveman coming across a modern car and trying to figure out how to make it. "It would be like taking the engine out of the car, starting it up, and trying to see how that engine works" (Simpson, 1999, p.26).

Some bacteria, specifically phototrophs and lithotrophs, contain all the metabolic machinery necessary to construct most of their growth factors (amino acids, vitamins, purines and pyrimidines) from raw materials (usually O₂, light, a carbon source, nitrogen, phosphorus, sulfur and a dozen or so trace minerals). They can live in

an environment with few needs but first must possess the complex functional metabolic machinery necessary to produce the compounds needed to live from a few types of raw materials. This requires more metabolic machinery in order to manufacture the many needed organic compounds necessary for life. Evolution was much more plausible when life was believed to be a relatively simple material similar to, in Haeckel's words, the "transparent viscous albumin that surrounds the yolk in the hen's egg" which evolved into all life today. Haeckel taught the process occurred as follows:

By far the greater part of the plasm that comes under investigation as active living matter in organisms is metaplasm, or secondary plasm, the originally homogeneous substance of which has acquired definite structures by phyletic differentiations in the course of millions of years (1905, p.126).

Abiogenesis is only one area of research which illustrates that the naturalistic origin of life hypothesis has become less and less probable as molecular biology has progressed, and is now at the point that its plausibility appears outside the realm of probability. Numerous origin-of-life researchers, have lamented the fact that molecular biology during the past half-a-century has not been very kind to *any* naturalistic origin-of-life theory. Perhaps this explains why researchers now are speculating that other events such as panspermia or an undiscovered "life law" are more probable than all existing terrestrial abiogenesis theories, and can better deal with the many seemingly insurmountable problems of abiogenesis.

Acknowledgements: I want to thank Bert Thompson, Ph.D., Wayne Frair, Ph.D., and John Woodmorappe, M.A., for their comments on an earlier draft of this article.

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Editor's Note

The *Quarterly* has published numerous items on the same subject as Dr. Bergman's article. Readers should find the following references of interest.

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“Some of the Injuns have stories about what they call the Thunder-Bird, some great bird or flying thing that makes a noise like thunder. There was a Mexican whosaid something like that used to land in a lake, Lake Elizabeth, they called it. Used to kill his sheep sometimes. Then later there was a story about two cowboys who killed a flying reptile or something down in the desert in Arizona.”

Louis L'Amour. 1983. *The Lonesome Gods*. Bantam Books, New York. Ch. 27, p. 2

What is the Upward Limit for the Rate of Speleothem Formation?

George T. Matzko*

Abstract

The speleothem formation experiments conducted in the late 1970s by the Society have been resurrected at the Van Andel Creation Research Center. A new experimental apparatus has been constructed, other ancillary equipment collected and testing has begun. The earlier work is reviewed and the results of that research are summarized. The deposition of speleothems from a theoretical per-

spective, emphasizing the chemical processes involved, is considered. Recent advances in the age dating are examined. The factors that affect speleothem growth are discussed. Recent studies conducted in natural cave environments are mentioned. The kinetics of speleothem precipitation is being studied in an attempt to predict what natural conditions encourage rapid development.

Introduction

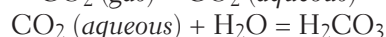
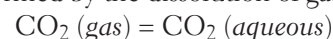
The rate of speleothem (stalagmite and stalactite) formation is an intriguing chemical problem that has been investigated by creationists on and off for the last 30 years (Gish, 1989). Creationist interest in this somewhat arcane topic derives from the obvious disparity between descriptions of slow speleothem growth rates normally touted by guides in commercial caverns compared to reports of rapid, even catastrophic, growth of dripstone formations in the uniformitarian and creationist literature (Gardner, 1935; Meyers and Doolan, 1987; Williams, et al., 1976; Williams and Herdclotz, 1977; 1978; Williams, House and Herdclotz, 1981; Williams, 1988b; Wolfrom, 1994). However, for dramatic appeal, nothing can surpass the Carlsbad Bat (Whitcomb, 1973). In October 1953, *National Geographic Magazine* published a photograph of a bat that was preserved in a stalagmite before it had a chance to decompose (Sutherland, 1953). The same photograph was used as a cover illustration for the September 1971 *Quarterly* (8:93).

For the sake of clarity, it should be mentioned what is not being considered in this article: the rapid formation of dripstone from concrete-mortared structures. Stalactite growth in this environment does not proceed by the same chemical reaction as it does in natural limestone caves (Williams and Herdclotz, 1977, p. 198; Williams, 1988a; Wise, 1988). Another important but related issue that is not covered in this article is the mechanism by which caves are formed in the first place. For specula-

tions on cave formation during and after the Flood, see Williams and Herdclotz, 1977, pp. 197–198; 1978, p. 88. One aspect of this problem which is pertinent to this discussion is the suggestion that sulfuric acid may have played a role in dissolving limestone during the early part of a cave's history (Moorehouse, 1968; Oard, 1998). If some caves have been formed by sulfuric acid dissolution, it may be possible that sulfuric acid also played a role in the formation of some of the older speleothems. Sulfate ions are normally found in water samples taken from caves. For example, calcite precipitating water samples from Warm River Cave, Virginia were found to contain from 128 to 438 mg/L SO_4^{2-} during tests in 1984 (Herman and Lorah, 1986). But as far as it is known now, the main effect of CaSO_4 on dissolution and precipitation rates of solid CaCO_3 is a common-ion effect (Buhmann and Dreybrodt, 1987). See earlier experiments on dissolution of limestone and dolomite by acid solutions in Williams and Herdclotz, 1977, pp. 193–194.

Chemistry of Speleothem Formation

What we do know is that the primary chemical agent involved in the formation of speleothems is carbon dioxide. The solubility of calcite in pure water is very small, about 6 ppm at 10°C, but carbonate minerals are readily soluble in acid, and the acid most important to karst processes is carbonic acid, formed by the dissolution of gaseous CO_2 :



The net reaction for the dissolution of calcite is:



*George T. Matzko, Ph.D., Chairman, Division of Natural Science, Bob Jones University, Greenville, SC 29614. Email: gmatzko@mbusa.net

Received 11 August 1999; Revised 12 November 1999

In most cases it is believed that calcite speleothems are formed when ground water which is supersaturated with CaCO_3 enters a cave. Outgassing of dissolved CO_2 lowers carbonate solubility in these drip waters and leads to crystalline calcite deposition.

The calculation of calcite deposition rates therefore hinges on the combinations and permutations inherent in carbonate equilibria. For example, the concentration of dissolved calcite varies with the cube root of the CO_2 partial pressure as follows (White, 1988, p.130):

$$m_{\text{Ca}^{2+}}^3 = P_{\text{CO}_2} \frac{K_1 K_c K_{\text{CO}_2}}{4K_2 (\gamma_{\text{Ca}^{2+}})(\gamma_{\text{HCO}_3^-})^2}$$

where:

K_1 and K_2 = equilibrium constants for the dissociation of carbonic acid.

K_c = the solubility product constant for calcium carbonate.

P_{CO_2} = the partial pressure of carbon dioxide.

α and γ = the activities and activity coefficients of the respective species.

K_{CO_2} = a bulk equilibrium constant that describes all neutral carbon bearing species:

$$K_{\text{CO}_2} = \frac{\alpha_{\text{H}_2\text{CO}_3}}{P_{\text{CO}_2}}$$

In addition to equilibrium relationships, the kinetics of calcite dissolution and deposition must also be considered. The kinetics are determined by three independent processes (Buhmann and Dreybrodt, 1985a):

- The kinetics of dissolution (or deposition) at the phase boundary between the solvent aqueous system $\text{CaCO}_3 - \text{H}_2\text{O} - \text{CO}_2$ and the limestone.
- The kinetics of the conversion of CO_2 to carbonic acid.
- Mass transport of the dissolved species, i.e. Ca^{2+} , HCO_3^- , CO_3^{2-} , CO_2 and H_2CO_3 , by diffusion from and to the phase boundaries.

The first kinetic model that included the three processes listed above, and therefore accounted for the mechanisms taking place at the surface of the CaCO_3 rock, is the Plummer-Wigley-Parkhurst model (Plummer, 1978). The Plummer-Wigley-Parkhurst or PWP equation gives the dissolution rate as a function of the species Ca^{2+} , H^+ , HCO_3^- and H_2CO_3 at the CaCO_3 surface:

$$F = \kappa_1 (\text{H}^+) + \kappa_2 (\text{H}_2\text{CO}_3^*) + \kappa_3 - \kappa_4 (\text{Ca}^{2+})(\text{HCO}_3^-)$$

where F is the flux of Ca^{2+} ions.

The first three rate constants are temperature (K) dependent:

$$\log \kappa_1 = 0.198 - 444T^{-1}$$

$$\log \kappa_2 = 2.84 - 2177T^{-1}$$

$$\log \kappa_3 = -5.86 - 317T^{-1}$$

The fourth rate constant is dependent on the activity of the aggressive agent and is given by Plummer, Wigley and Parkhurst (1978). The quantities in round brackets in the PWP equation are the activities of the corresponding species and $(\text{H}_2\text{CO}_3^*) = (\text{H}_2\text{CO}_3^0) + (\text{CO}_2)$. Note that because the PWP equation is a rate equation, containing forward and backward reactions, it is valid for the precipitation of CaCO_3 as well as its dissolution. All that is required is to change the sign of F (Inskeep and Bloom, 1985).

The PWP model has been tested extensively under a variety of conditions (Buhmann and Dreybrodt, 1985b; Dreybrodt and Buhmann, 1991; Dreybrodt, et al., 1992; Liu and Dreybrodt, 1997; Fairchild, et al., 1999). During these tests the dissolution or precipitation rates were found to roughly correspond with the equation,

$$R = \alpha ([\text{Ca}^{2+}]_{\text{eq}} - [\text{Ca}^{2+}])$$

(Buhmann and Dreybrodt or B-D model), where α is a function of CO_2 pressure, thickness of the water film covering the CaCO_3 surface, and temperature. $[\text{Ca}^{2+}]_{\text{eq}}$ is the concentration at saturation and when

$$[\text{Ca}^{2+}] \geq 0.2[\text{Ca}^{2+}]_{\text{eq}}.$$

For example, at a P_{CO_2} of 5×10^{-3} atm and a temperature of 10°C , $[\text{Ca}^{2+}]_{\text{eq}}$ has a value of 16.2×10^{-4} mmol cm^{-3} and α , the rate constant, is equal 1.54×10^{-5} cm s^{-1} for a laminar core (diffusion layer) thickness of 0.01 cm. Note also that rates of deposition given in mmol $\text{cm}^{-2} \text{s}^{-1}$ can be converted into a speleothem growth rate given in cm/yr. by multiplying by the factor $1.17 \times 10^6 - \text{cm}^3 \text{s mmol}^{-1} \text{yr}^{-1}$. This assumes that the calcite is deposited in such a way that it is compact (Baker, et. al., 1998).

As an example of a theoretical growth rate calculation of a speleothem, assume the laminar flow conditions listed above and a 400 ppm CaCO_3 solution where we have $[\text{Ca}^{2+}] = 0.004$ mmol cm^{-3} , $\alpha = 1.54 \times 10^{-5}$ cm s^{-1} , and $[\text{Ca}^{2+}]_{\text{eq}} = 16.2 \times 10^{-4}$ mmol cm^{-3} .

With these values the B-D model yields a deposition rate of 3.67×10^{-8} mmol $\text{cm}^{-2} \text{s}^{-1}$ or a 0.0429 cm/yr. growth rate.

Age Dating of Speleothems

While a growth rate of 0.0429 cm/yr. may seem impressive, yielding a two and a half-meter stalactite in 6,000 years, it still falls short of the values for recent cave deposits measured by the relatively new, excess ^{210}Pb technique.

Citing the difficulty in obtaining reliable dates from the ^{14}C method (Williams and Herdtklotz, 1977, p. 198) because of the multiple sources of carbon in speleothems, Baskaran and Iliffe (1993) conducted the first study of short-term (1–100 yr.) growth rates using a relatively short-lived isotope such as ^{210}Pb . ^{210}Pb (half-life = 22.1 yr.)

is produced from its gaseous precursor, ^{222}Rn (half-life = 3.8 d) at a constant rate. Most of the ^{222}Rn in cave air is presumed to have degassed from ground water at the same time that CO_2 is degassed from the water dripping into caves. Drip waters from the ceilings of caves have high concentrations of ^{222}Rn . Baskaran and Illiffe (1993) measured the ^{210}Pb in various sections of a 126-mm soda straw stalactite from Harrel's Cave, Texas. They found that the concentration of ^{210}Pb exhibits an exponential decrease with distance from the bottom of the soda straw. This data yielded a longitudinal growth rate of 1.1 mm/yr. and an age of 115 yr. A 23mm wide icicle shaped stalactite from the same cave, which formed around a soda straw having a central diameter of 5mm, was tested by the same method and yielded a lateral growth rate of 0.031 mm/yr. with an age of 581 yr. Interestingly, an inner core sample of the same icicle stalactite was analyzed by the ^{14}C technique and dated at an age of 7460 yr. The authors believe that their values compare favorably with tradition growth rates such as the 2 mm/yr. rate reported by Moore and Sullivan (Moore, 1978).

A Japanese group (Tanahara, et. al., 1998) using the same excess ^{210}Pb dating method, measured the ^{210}Pb profiles of two soda straw stalactites collected from a natural cave at Tamagusuku, Okinawa Island, Japan. They obtained growth rates of 2.2 and 5.9 mm/yr. respectively. One would expect growth rates of straws to vary even in a single cave, depending on running and dropping rates of water, but a 5.9 mm/yr. rate over 6,000 yr. is capable of producing a stalactite 35 meters long!

Are higher stalactite growth rates than these possible? What factors could be responsible for producing even greater rates of growth? A growth rate of 5.9 mm/yr. corresponds to a $[\text{Ca}^{2+}]$ of 3.4×10^{-2} mmol/cm or 3,400 ppm CaCO_3 using values of, $\alpha = 1.54 \times 10^{-5} \text{ cm s}^{-1}$, and $[\text{Ca}^{2+}]_{eq} = 16.2 \times 10^{-4} \text{ mmol cm}^{-3}$ in the B-D equation. How are such high concentrations obtained? Consider each of the possible factors in turn.

Temperature and Speleothem Growth

Calcite speleothems are found to form in caves beneath icefields (Gascoyne and Nelson, 1983). In temperate and tropical climates the dissolved CO_2 required to dissolve limestone formations is thought to primarily come from gas uptake from decaying organic matter (even to the extent of 16–20 % CO_2 in the soil measured during a monsoon in India) [Adams and Swinnerton, 1937]. See Williams and Herdtklotz, 1977, pp. 192–193 for a discussion of the CO_2 content of water in natural situations. Such a mechanism is not possible in areas devoid of biological activity; although venting of CO_2 from deep within the earth's crust should not be automatically ruled out.

Dreybrodt (1982) proposed a temperature effect mechanism in order to account for the formation of speleothems in caves covered by glaciers or bare karst. Under a glacier there is abundant melt water at 0°C that can penetrate into the fissures of the limestone rock. On the way through the limestone rock to the cave, its temperature is increased by a few degrees and since the solubility of CO_2 decreases with increasing temperature, the solution becomes supersaturated and the deposition of calcite can occur. By this mechanism alone, a solution with a temperature of 2°C entering a cave with the same temperature can be responsible for a growth rate of $1 \times 10^{-3} \text{ cm/yr.}$ all by itself. Depending on the water film thickness, a 5°C differential could easily be responsible for a growth rate of $5 \times 10^{-3} \text{ cm/yr.}$ Williams and Herdtklotz, 1977, pp. 195–197 conducted experiments on the effect of temperature on CaCO_3 solution and deposition. The results are summarized in Tables I and II.

Pressure Difference and Speleothem Growth

It is well known that CO_2 solubility in water not only increases with decreasing temperature but also increases with increasing pressure. Presumably there is some hydrostatic pressure responsible for pushing the ground water through microscopic fissures in the limestone. Unfortunately, a typical pressure gradient from the surface to the cave ceiling would be difficult to quantify. However, it is safe to say that as the water enters the cave, the pressure on the water drops. As the pressure drops, the solubility would also drop and CO_2 would be free to outgas. Several experiments were run in the 1970s employing this concept, and the results are summarized in Tables I and II.

Hydrogen Ion Concentration

The equilibrium pH of the $\text{CaCO}_3 - \text{H}_2\text{O} - \text{CO}_2$ system is well defined for every value of CaCO_3 concentration, CO_2 pressure and temperature (White, 1988. p.131). However, in caves, as opposed to controlled laboratory conditions, the pH is often controlled by other reactions in the system (Garrels, 1965, p.75). For example, pH measurements of cave waters in Indian Echo Cave, PA ranged from 7.67 to 9.91 (Holland et. al., 1962). The 9.91 reading came from a "small pool fed largely by water from a soda straw" and had a concentration of 194 ppm CaCO_3 while the water dripping from the soda straw had an average pH reading of 7.74 and a calcium carbonate concentration of 289 ppm. Water samples taken from Luray Caverns, VA by the same group had a pH range from 7.32 to 8.05. One final example: A small calcite precipitating stream named Westerhofbach located near the village of Westerhof, Germany has been studied more recently (Dreybrodt et al.,

Table I. Test Conditions During Calcium Carbonate Dissolution and Precipitation Experiments

Experiment Designation	Test Time (hours)	Description of Rig	Test Solution	Rock Being Dissolved	Test Temp (°C)
A	700	Ref. 1, p. 212	tap water	Indiana Limestone	25
B	500	Ref. 2, p. 192 (same as A)	+ CO ₂ tap water + CO ₂ + 5% NaCl	(same as A)	(Same as A)
C	NR	Ref. 2, p. 195	tap water + CO ₂ + 1% Acetic acid	Indiana Ls, Beekmantown Dolomite	(same as A)
D	450	(same as C)	demineralized Water + CO ₂	Beekmantown Dolomite	45–50
E	600	(same as C)	(same as D)	(Same as D)	(same as D)
F	500	(same as C)	(same as D)	(same as D)	8–25
G	502	Ref. 3, p. 89	demineralized Water + CO ₂ + NH ₃	(same as D)	25
H	500	Ref. 4, p. 205	demineralized Water + CO ₂	(same as D)	(same as G)
I	1314	(same as H)	(same as H)	(same as D)	(same as G)
J	600	Ref. 4, p. 207	(same as H)	(same as D)	(same as G)
K	600	(same as J)	(same as H)	(same as D)	(same as G)

NR: Not recorded; LS: Limestone

Ref. 1: Williams et al., 1976; Ref. 2: Williams and Herdtklotz, 1977; Ref. 3: Williams and Herdtklotz, 1978; Ref. 4: Williams, House and Herdtklotz, 1981.

Table II. Test Results of Calcium Carbonate Dissolution and Precipitation Experiments.

Experiment Designation	Amount of CaCO ₃ ppt. (grams)	CaCO ₃ ppt. per year (grams)	Amount of Solution Consumed (liters)	Amount of CaCO ₃ ppt. per liter of Water (grams)	Likely Mechanism of CaCO ₃ ppt.
A	1.7962	22.51	NR	NA	Pressure Difference Temperature and Chemical differences
B	4.4554	78.05	209	0.0213	
C	0	0	NR	0	
D	6.4413	125.36	450	0.0143	Temperature and Pressure differences
E	9.4288	137.66	600	0.0157	(same as D)
F	9.9007	173.46	500	0.0198	(same as D)
G	1.0184	7.08	1260	0.0008	Pressure difference
H	2.7036	47.37	118	0.0229	(same as G)
I	3.9386	26.25	1314	0.003	(same as G)
J	10.6556	155.57	472	0.0226	(same as G)
K	12.8434	187.51	191	0.0672	(same as G)

NR: Not recorded; NA: Not available.

1992). Along the 265-m long stream, the pH varied between 7.69 upstream to 8.48 downstream. The greatest deposition rate ($6.50 \times 10^{-8} \text{ mmol cm}^{-2} \text{ s}^{-1}$) was measured at station #7 where coincidentally the pH was 8.48. Qualitative pH measurements were made in a natural cave and quantitative pH measurements were made in laboratory situations. These results were reported in Williams et al., 1976, p. 212; Williams, House and Herdtklotz, 1981.

Carbonates dissolve at a much faster rate in solutions of low pH (Stumm and Morgan, 1996, p. 791). Therefore, it is not unreasonable to suppose that in some cases that limestone is dissolved at a rapid rate by acidic waters close to the surface and becomes increasingly alkaline as the water travels through layers of soil and rock. It would become, as a result, increasingly supersaturated with calcium carbonate before it drips from the cave ceiling. Such a mecha-

nism, though hard to prove, would be more prominent during early stages of a cave's history before the alkalinity has been washed out of the soil and rock.

Flow Velocity and Turbulence

Weyl (1958) discussed the idea that the rate of solution of calcite is proportional to the flow. White and Longyear (1962) were responsible for introducing the concept of "hydraulic jump," a sudden transition in the distance that water will have penetrated into limestone at 90% saturation, as the velocity increases. This penetration distance increase is not a small effect according to White and Longyear. They state (p.163) that "the effectiveness of solution increases by seven orders of magnitude at the jump." Buhmann and Dreybrodt (1985a) confirmed this hydraulic jump by calculating the dissolution rate using the B-D equation for various boundary layer film thicknesses, d , which are inversely related to velocity and turbulence). For $d < 0.003$ cm, α increases nearly linearly with d . This is the region in which the conversion of CO_2 into H_2CO_3 is rate determining. At $d = 0.03$ cm a threshold is reached and above 0.05 cm the dissolution rate decreases. However, in a turbulent system, the rates are determined entirely by surface-controlled processes and the PWP equation holds. Buhmann and Dreybrodt calculated that the rates of dissolution would increase about one order of magnitude for turbulent flow situations. Lauritzen investigated dissolution rates in a phreatic cave conduit by analyzing the chemical composition of the water at the inlet and exit of the conduit (Dreybrodt and Buhmann, 1991). At low flow rates ($1 \text{ m}^3 \text{ s}^{-1}$) the observed dissolution rates were small, but at flow rates above $10 \text{ m}^3 \text{ s}^{-1}$ the dissolution rate increased to maximal value of $1 \times 10^{-7} \text{ mmol cm}^{-2} \text{ s}^{-1}$. Further confirmation of the importance of flow rates has come from rotating disk dissolution experiments (Liu and Dreybrodt, 1997). By rotating a calcite disk in solutions of various temperatures and CO_2 partial pressures and measuring dissolution rates by electrical conductivity measurements, Liu and Dreybrodt were able to confirm the applicability of the B-D model for turbulent solutions. For example, at a rotating speed of 100 rpm (10°C , $P_{\text{CO}_2} = 3 \times 10^{-4} \text{ atm.}$) the measured dissolution rate was $8.0 \times 10^{-8} \text{ mmole cm}^{-2} \text{ s}^{-1}$, but at a rotating speed of 3000 rpm the rate had increased to $28.8 \times 10^{-8} \text{ mmole cm}^{-2} \text{ s}^{-1}$.

The velocity and turbulence of ground water flow through the cracks and fissures in limestone is a complex subject and rates vary from one karst area to another depending on various geometrical, hydraulic and chemical parameters (Dreybrodt, 1996). However, it is safe to say that calcium carbonate supersaturation will increase during times of higher flow rates such as heavy rain storms and floods. Williams and Herdtklotz (1977, pp. 197–198) discussed the possible effect of rapidly-moving, receding

Floodwater through limestone fissures. If the depth of water was 1000 ft. above an opening in the rock, the velocity of flow could be as great as 80 ft s^{-1} .

Drip Rates

The average molecular accumulation rate between two drops falling onto a calcite surface at a time interval T has been shown by Dreybrodt (Baker, et al., 1998) to be

$$R_{acc} = \frac{(c - c_{eq})\delta}{T(1 - \exp(-\frac{T}{\tau}))} \text{ mmol cm}^{-2} \text{ s}$$

where

$$c_{eq} = (-0.01t + 0.72) \cdot 10^{-3} (\text{mol} \cdot \text{l}^{-1}) \text{ and } \tau = \frac{\delta}{\alpha}.$$

where:

R_{acc} is the accumulation rate assuming that $T \geq 0.2\delta/\alpha$.

c is the concentration of Ca in the water film in mmol/cc.

c_{eq} is the equilibrium concentration of Ca, which depends entirely on the temperature t in $^\circ\text{C}$ as shown above.

δ is the thickness of the water film in cm.

T is the interval of time between drops.

τ is the time constant and α is the kinetic constant in cm/s.

It can be seen from the equations above that the maximal growth rates for stalagmites will occur when the drop rate is fast enough to keep the surface covered with a thin film of optimal thickness ($\cong 0.03$ cm) in order to allow the CO_2 to degas. Perhaps this is one reason why stalactites can sometimes appear with a complementary stalagmite and sometimes not. Stalagmite growth appears to be much more dependent on the drip rate dynamics. In a quantitative study of drip rate Williams, House and Herdtklotz (1981, pp. 205–206) found that CaCO_3 deposition increased to a maximum as the drip rate decreased. Then the amount of precipitate decreased upon further lowering of drip rate indicating a possible optimum drip rate for maximum deposition.

Observations and Experimentation on Speleothem Formation

In the 1970s, those working on the problems associated with speleothem formation were limited to using chemical equilibrium calculations as a starting point to predict the rate of speleothem formation. The theoretical models developed since that time, especially the PWP and B-D models now provide an excellent starting point for calculating actual speleothem growth. For example, it used to be thought that models like these were generally valid for

pure substances, but not for natural limestones and dolomites that contain impurities that may have an effect on CaCO_3 dissolution and subsequent precipitation. We now know, in the words of Buhmann and Dreybrodt, that “although foreign ions displace the calcite solution equilibria, by the effect of ion-strength, ion-pairing and the common-ion effect, the kinetics of the dissolution process are hardly changed” from that predicted by the B-D model (Buhmann and Dreybrodt, 1987, p. 89.). In addition to the theoretical advantages offered to workers in the next millennium there are also computer programs on the market that are able to model groundwater behavior in detail. The Van Andel Creation Research Center is in the process of obtaining a software package of this type. The challenge for the experimentalist will be to duplicate the non-equilibrium conditions found in natural settings. For example, natural water laden with CO_2 may travel hundreds of feet through jointed limestone before entering a cave where CO_2 can be released (due to a pressure difference) causing CaCO_3 deposition. Since most test rigs are limited in size, it is almost impossible to achieve a lengthy water travel path that would reflect a natural situation. The only practical solution may be to recycle the test solution thereby increasing the time of exposure to the test rocks as well as increasing the travel length of the fluid in order to effect more calcium carbonate dissolution.

In all of the previous experiments sponsored by the Society, it was found that:

The onset of precipitation...does not occur until a certain “incubation” time...has passed where no apparent precipitation takes place. After this time the precipitate became obvious and growth is visible (Williams, House and Herdtklotz, 1981, p. 207).

Also a pH change accompanied the precipitation “event”—the pH of the water with dissolved carbon dioxide and calcium was 8.27. Upon deposition of CaCO_3 , the pH of the solutions was lowered to 8.15 (Williams, House and Herdtklotz, 1981, pp. 207–208). This is a puzzling result since it appears to be in opposition to the measurements made in Indian Echo Cave and other locations mentioned above where the pH generally increases as the CaCO_3 is deposited.

If it can be determined what factors retard precipitation, then eliminate them, reducing the “incubation” time, it may be possible to speed up the precipitation reaction for speleothem formation and growth. If any of the above conditions can be related to the theoretical models presented previously, then considerable insight into speleothem development processes can be gained. This information in turn could, hopefully, be used to predict the conditions necessary for rapid formation.

The test conditions and results from the experiments conducted in the late 1970s are collected and summarized

in Tables I and II. Hopefully, the data are easier to discern in this format rather than scattered throughout the four reports published from 1976–1981. These reports are referenced and any details needed for further study can be found in them. One of the columns in Table II records the amount of CaCO_3 precipitate obtained per liter of water passing through the test rig. Obviously water flow into a vented cave is necessary for the formation of speleothems and generally the more water seeping into a cavern, the more CaCO_3 precipitation will occur (Williams and Herdtklotz, 1978, p. 88). Considering a Flood model of earth history, the postulated wet conditions (warm ice age) immediately after the Flood would encourage speleothem formation in caverns in the vadose zone.

Conclusion

Many times, actual rapid growth rates of speleothems have been observed in caves—as high as 1 inch per 7.5 days (4 inches/month) (Williams, House and Herdtklotz, 1981, pp. 208, 226). The trend in literature also has been moving toward faster growth rates especially among those who are pioneering the use of the excess ^{210}Pb dating method. Additional experiments need to be performed in order to optimize the various factors that have the potential to increase growth rates by another order of magnitude, temperature, pressure, pH and flow gradients all need to be explored again under controlled conditions before we can obtain a definitive answer to this important question.

Acknowledgments

The author gratefully acknowledges the financial support received from the Research Fund of the Creation Research Society for this project and the encouragement and help he has received from Dr. Emmett Williams and Dr. John Meyer.

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Book Review

Did God Create in Six Days?

Edited by Dr. Joseph A. Pipa, Jr. and Rev. David W. Hall

Southern Presbyterian Press, P.O. Box 690, Taylors, SC 29687. 1999, 339 pages, \$18

There is an ongoing debate over the interpretation of Genesis 1 in the Presbyterian Church in America (PCA). The issue was raised by a number of Presbyteries and individuals in the church following the publication of an annual report from the denominational seminary (Covenant, Saint Louis) noting the latitude of beliefs regarding the Genesis account of creation within the faculty. The seminary administration and faculty rightfully protested that nothing at the seminary has changed in forty years. Their stasis has been overtaken by an awareness in the denomination at large that this issue is important. Those who want to accept both the Bible and modern science reference many post-1800 reformed scholars for their overly-tolerant views of evolution and the supposed great age of the earth, a position unfortunately (but not uniformly) common to the reformed academic elite this century. Too little has been heard of defenders of Genesis such as Dr. Robert L. Dabney and their able sons, such as Dr. D. James Kennedy. Since the issue has been raised to the highest church court, the General Assembly, the governmental structure of the PCA must force a resolution of the issue, in spite of any discomfort. A study committee has been appointed and we should all pray that God would lead the PCA into a more faithful position on these important issues.

Greenville Presbyterian Theological Seminary (GPTS) in South Carolina has responded to the issue by taking a strong theological stand for the sequential, chronological interpretation of Genesis 1 and its corollary of a young earth. In order to clarify arguments from both sides for the study committee, the seminary recently sponsored a disputation, inviting prominent theologians advocating non-literal interpretations to debate the seminary faculty. The proceedings of this symposium have just been published and released by the seminary as the book, *Did God Create in Six Days?* Although scientists of CRS may not all be greatly interested in the wealth of material specific to the Presbyterian tradition in this book, they should enjoy the presentation and critiques of the “day-age” position, the “Framework Hypothesis”, and a new style of interpretation called “Discourse Analysis”. Theological critiques of major non-literal views of Genesis 1 are ably provided by the seminary faculty. The contribution by Dr. Pipa, “From Chaos to Cosmos: A Critique of the Non-Literal Interpretations of Genesis 1:1–2:3” is especially helpful and thor-

ough. Although scientists tend to easily get bogged down in the apparent minutiae of theology, they would be well advised (as would anyone else) to spend a little time in this book. After all, not everyone is a scientist, but everyone is a theologian.

Two other contributions of special note are one by Rev. David Hall of Oak Ridge, Tennessee and another by Dr. Stuart Patterson, former Dean and Chemistry Department Chairman at Furman University. Rev. Hall has researched the position of pre-nineteenth century theologians, and does a masterful job of refuting the false claims of those theistic evolutionists (e.g., Hugh Ross) who seek company with the great theologians of the past. Rev. Hall shows that these giants of the past are often misunderstood and sometimes deliberately misrepresented. The great debate of the 17th century about the time of creation was not millions of years, but millionths of a second! Augustine of Hippo had concluded that God had created instantaneously; seventeenth century theologians opted for a literal interpretation of Genesis 1. This debate obviously had nothing to do with uniformitarianism, a fact lost on those who today see old earth views in the ancient church fathers. Rev. Hall’s conclusions will carry great weight with the PCA, a confessional church that has adopted the theology and polity of the 17th century Westminster standards. Written records from the Westminster divines, available at present, are shown to be unanimous in their support of the 24-hour day, young earth interpretation of Genesis. Finally, for those who can survive the theological tidal wave of the first few hundred pages, Dr. Patterson provides a concise summary of the scientific evidences pertinent to the age of the earth.

Although I freely admit a built-in bias towards this book because of a long association and friendship with both Dr. Patterson and Dr. Pipa, I would encourage the readers of the *Quarterly* to see for themselves how helpful and timely this book is, and to contradict the statement of Rev. Hall who stated that after ministering for some time in a highly scientific community he found “that most (not all, fortunately) practicing scientists were as philosophically sophisticated as most NFL players.” Reading this book would be a good start away from being a “Super Bowl Socrates”.

John K. Reed
915 Hunting Horn Way
Evans, GA 30809

Notes from the Panorama of Science

Rock Spires (Pseudo-Hoodoos) on the Lookout Mountain Syncline

An interesting paradox exists with regard to the Lookout Mountain synclinal ridge. Today, the ridge stands over one thousand feet above the adjacent valley floors, but at one time it was the lowest point between two areas of uplift (Figure 1). It extends from just north of Gadsden, Alabama to Chattanooga, Tennessee, a distance of approximately 80 miles. Several young-earth studies have reported on various sections of this geomorphic feature (Akridge, 1998; Froede, 1997a, b, c). Ongoing creationist research continues in this region to interpret the many features within Bible-based Flood stratigraphy and geomorphology.

Geology of the Rock Spires (Pseudo-Hoodoos)

Our exploration of Lookout Mountain near DeSoto Falls and Little River Canyon identified several areas where rock spires (pseudo-hoodoos) are found (Figure 2). Geo-

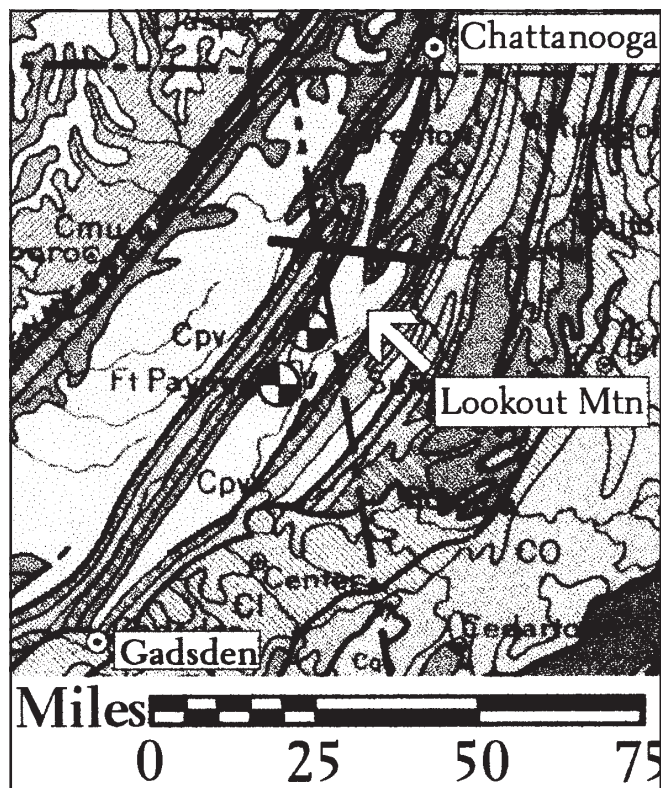


Figure 2. Our area of investigation for the rock spires is from DeSoto Falls to the Little River Canyon (black and white circles). Based on the exploration of this area, we believe that many other areas across the top of this syncline contain similar rock spires in varying degrees of development. Additional field work is needed to confirm or refute our speculations. Base map modified from the United States Geological Survey map of the United States.

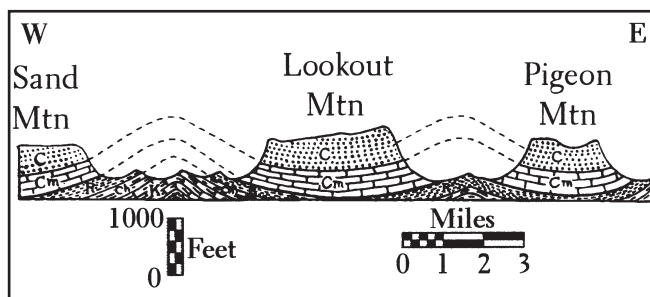


Figure 1. Generalized cross-section through the Lookout Mountain synclinal ridge (see black bar in Figure 2 for location of this section). The ridge was at one time the lowest point between two anticlinal areas of uplift. Erosion removed the uplifted areas and created the elevated synclinal ridge. See Akridge (1998) and Froede (1997c) for a creationist description of the processes believed to be responsible for the formation of this synclinal ridge. Section modified from Spencer, 1893, p. 18, Figure 6.

logically, it appears that they occur within the Pennsylvanian Warren Point Sandstone as identified and delineated in Georgia (Crawford, 1989) and the Pennsylvanian undifferentiated Pottsville Formation in Alabama (Osborne, Szabo, Neathery, and Copeland, 1988). Interestingly, high-angle cross-bedded quartz-pebble channel lag was exposed in the spires. The rock spire stratigraphic unit is described as:

Sandstone, fine-to-course-grained, feldspathic; cross-bedded in sets up to 20 feet thick; ranges from thin- and medium-bedded to massive. Channels tens of feet deep contain massive conglomeratic sandstone and quartz-pebble conglomerate. Siderite-pebble conglomerate at lower contact (Crawford and Brackett, 1989, Plate No. 7).

From our field work we noted a relationship between the siderite (FeCO_3) pebble conglomerate (Figures 3 and 4) and the overlying highly cross-bedded quartz-pebble bearing sandstone. We conjecture that connate water (i.e., water filling the pore spaces between the sand grains) trapped within the massive semi-lithified sandstone moved laterally to points of discharge along newly exposed sidewalls. This occurred as this stratigraphic unit was thrust laterally and warped tectonically during the Flood. Tremendous erosion of the sandstone layer occurred concurrently with this tectonism, and played a significant role in the eventual formation of these rock spires. As the pH and Eh likely changed within the sandstone, iron (i.e., siderite) probably was precipitated from the connate water. It appears that the majority of the iron was precipitated at the base of the sandstone unit where it contacted an impermeable shale unit.

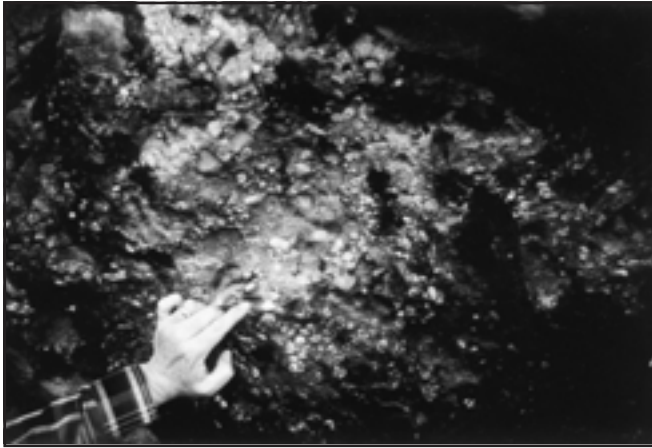


Figure 3. A photograph showing the quartz-pebble conglomerate cemented by silica and a small amount of siderite (FeCO_3). We believe that the differences in cement composition contributed to the formation of the rock spires (pseudo-hoodoos) within this sandstone unit. However, further investigation is needed to substantiate these claims.



Figure 4. A photograph showing a quartz-pebble conglomerate from the bottom-most section of the rock spire layer which was cemented completely by siderite (FeCO_3). This is a weak cement compared to the quartz-cemented sandstones in the upper sections of this layer.



Figure 5. A photograph of an exposed wall of quartz-cemented sandstone in the Citadel Rocks area. Akridge is pointing to a fracture where siderite has precipitated forming an iron-rich lens. These sandstones do not contain high concentrations of siderite cement, but they do reveal substantial levels of iron along joints and fractures.



Figure 6. A photograph showing bedding planes of the sandstones in the Citadel Rocks area. Iron mixed with the sandstones following deposition and precipitated along these bedding features.

According to our observations, the iron was probably not derived from the dewatering of the shales beneath the massive sandstone layer. All the iron precipitation was diagenetic (i.e., post depositional). It filled fractures within the massive sandstone unit and enhanced the joint sets in a manner similar to Liesegang rings (Figures 5 and 6).

We also located areas where rock spires appear to be in the initial stages of formation. These underdeveloped features may hold the key to a better understanding of this area and demonstrate how the rock spires may have formed (Figure 7). From our early reconnaissance of this area, we speculate that cliff-sapping might have played a large role in the formation and development of these inter-

esting features, although further analysis is needed to ascertain this.

Geomorphology of the Rock Spires (Pseudo-Hoodoos)

The rock spires vary considerably in size and shape (Figures 8 and 9). All of the rock spires that we examined had a semi- to impermeable quartz cemented sandstone cap which protects the underlying softer strata (much of which contains iron cement) from weathering (Figure 10). The rock spires tend to occur along the crests of ridges or in topographically high areas. This consistent location supports our speculations about the role that cliff-sapping may have



Figure 7. A photograph showing the beginnings of rock spire formation in the Citadel Rocks area. Individual pedestals of sandstone lie within close proximity to one another. We believe that this setting reflects the massive erosion that this area experienced and the manner by which the rock spires formed.



Figure 8. A rock spire (pseudo-hoodoo) in the Little River Canyon National Preserve. A silica-cemented cap rock protects the underlying siderite-cemented sandstones from erosion.



Figure 9. A smaller rock spire located near the Sallie Howard Memorial Chapel. Not surprisingly, the pseudo-hoodoos vary in size as a function of the characteristics of the individual cap rocks.

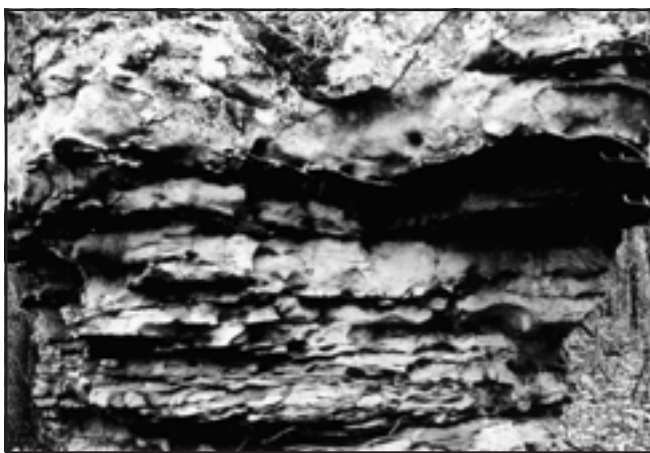


Figure 10. A close-up photograph of Figure 9 showing the massive sandstone cap rock above siderite cemented cross-beds of underlying sandstone. The siderite cement varies in thickness and appears to follow bedding planes. These sedimentary features perhaps reflect preferential connate water flow paths where the siderite precipitated.

had in being a major factor in the formation of these features.¹

The rock spires identified on Lookout Mountain in Georgia, within the Warren Point Sandstone (Froede, 1997a), are identical to those we examined on Lookout Mountain in this area of Alabama. Both occur in similar settings along ridge lines. Weathering appears to be enhanced along joints and fractures, easily identified by the siderite cement and associated iron stain.

¹Discussions regarding how cliff-sapping might possibly be associated with rock spire development can be found in Williams (1995) and Shaver (1999)

Rock Spire at the Sallie Howard Memorial Chapel

The most unique rock spire location that we found occurs at the Sallie Howard Memorial Chapel, a Southern Baptist church located adjacent to DeSoto State Park (Figures 11, 12, and 13). The following is excerpted from the DeKalb Baptist Association church information brochure:

The Chapel was constructed in 1937 under the direction of an ailing Colonel Milford Howard in honor of his deceased wife, Sallie Howard. It is modeled after the Annie Laurie Church in Scotland after Colonel Howard admired a reproduction of that church located in Glendale, California. The Chapel



Figure 11. The Sallie Howard Memorial Chapel. A large rock spire has been incorporated into the front of the church.



Figure 12. Another photograph showing the opposing side of the pseudo-hoodoo which is incorporated into the front of the church.

was dedicated on Sunday afternoon, June 27, 1937. Colonel Howard died in California on December 28, 1937. Colonel Howard's ashes are interred under a bronze marker within the rock spire near the pulpit in the chapel he built on Lookout Mountain.

Conclusions

The rock spires (pseudo-hoodoos) of various shapes and sizes found on top of the Lookout Mountain synclinal ridge, occur in Pennsylvanian age strata, specifically the Warren Point Sandstone and undifferentiated Pottsville Formation. They are consistently found along ridges and elevated areas. It appears that the strata were originally formed under high-energy conditions during the global Flood of Genesis and likely derived from sediments associated with the uplift of the Southern Appalachians (Froede, 1998). Subsequent erosion, occurring during a high-energy portion of the Flood, removed sections of the highly



Figure 13. A photograph looking at the front of the church. Note the bedding planes of the sandstone and the slightly offset jointing of the rock spire.

cross-bedded semi-lithified sandstone. Diagenetic processes served to further lithify the sandstone with silica and iron cements. The iron cement was precipitated mainly along the base of the sandstone unit, although it is also prevalent along fractures and joints within the sandstone. It appears that the iron-cemented sandstone is less resistant to erosion than the silica cemented upper section of the same unit. We believe that this may have aided in the formation of the rock spires through the process of cliff-sapping. Further field work is necessary to confirm these observations.

The rock spires now stand as a silent testimony of powerful erosive forces and processes which occurred during the time of their formation. Because in many places the spires extend as much as 12 to 15 feet above the surrounding land surface, huge volumes of sediment were removed to form them. This approach to defining and understanding these rock spires (pseudo-hoodoos) can best be understood within the constraints of the Young-Earth Flood model.

The uniformitarian depositional paleoenvironment of a prograding delta cannot satisfactorily explain the apparent high-energy conditions which were necessary in the formative process of these sandstone and quartz-pebble conglomerates (Froede, in press). Additionally, the millions of years of uniformitarian-style weathering fail to explain the manner in which the rock spires may have formed. Rather, the high-energy nature of the sedimentary deposits speaks of catastrophic processes which would be expected during the global Flood of Genesis (Froede and Wallace, 1999). The formation of the rock spires through cliff-sapping of the incompletely lithified sandstone indicates that short periods of time elapsed between deposition and erosion, this being consistent with the Young-Earth Flood Model.

Acknowledgments

We thank our wives for allowing us the opportunity to conduct field work within this most interesting and beautiful area of Alabama. We thank our Creator for providing so many apparent evidences of a global Flood and young Earth. Psalms 8:1.

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A. Jerry Akridge
2626 Pine View Dr., NW
Arab, AL 35016-4548
Carl R. Froede, Jr.
2895 Emerson Lake Drive
Snellville, GA 30078-6644

“Is the goal of science to better understand the physical and life processes present today, or is it to put together dogma concerning the origins of the universe and man? The former is a legitimate use of scientific theory; the later is the use of theories to form a religion, since there is no way to show whether the theories are right. The best that can be done is to prove they are logical.”

This quotation of Jerry Thouson, *Chemical and Engineering News*, October 1984 was used by Frederic B. Jueneman, *Research and Development*, December. 1984, p. 17. Jueneman's source for the quotation was *Chemical and Engineering News*, October 1984, where Jerry Thouson was discussing the inflationary universe theory as described in the May 1984 issue of *The Scientific America* article titled, “The Inflationary Universe.”

Fossil Man

This is a brief note on the present position of the fossil record of man and of the non-human primates that play a part in the overall story of human origins. The skulls of Steinheim and Swanscombe are dated on the evolution scale at about 300,000 years (Gore, 1997, p.105). There are new discoveries in Spain of *Homo sapiens* reckoned to be equally ancient (Arsuaga, Martinez, Gracia, Carretera, and Carbonell, 1993). If we allow a history of about 50,000 years, we come to an overall age of 350,000 years. But at this point we can introduce the oldest spears as dating from 380,000 to 400,000 years ago, which left one author (Denell, 1997) speechless! Those spears can be seen in wonderful color on p.113 in *National Geographic* of July, 1997. The article shows what fine spears they really were. At present, spears are known to accompany remains of *Homo sapiens* only.

Homo erectus in the form of Peking Man is found at 500,000 years (Leakey, 1981, p.123). It can be seen from those dates that the gap between *sapiens* and *erectus* is closing and the shared features of elongated skulls and robust brow ridges could make these types of men the original. Certainly if one were to have the out-of-Africa model correct (i.e. man from one common origin) and if modern man came from *sapiens* with those elongated skulls, then the skulls at 300,000 years and the spears at 400,000 years would have to come out of Africa with *sapiens* around 400,000 to 500,000 years to give them time to travel the distances they did. At these times there is nothing in Africa that is modern enough to give rise to *sapiens*. Therefore, I, for one, dismiss all credibility of such evolutionary arguments.

A skull found in South Africa in Florisbad and dated at 260,000 years, however, has features that are close to modern man (Gore, 1997, p.99). Give this a history of its own and there would be even less time between the skulls at 300,000 years and this one at 260,000 years. Work by Dr. Rosalind Harding of Oxford University has traced back a gene found in Oxfordshire villagers to between 200,000 years and 400,000 years, but claims it originated in Asia. For a *sapiens* to have done this, however, an earlier time in Africa would be needed than the present timetable allows. It would be more akin to the dates mentioned in this paper and the question of who was the original man would still be raised. The date for Dr. Harding's gene is of course not looked at with great favor by those holding to the present timetable, but we must await further discoveries with interest (Connor, 1997, pp. 4–5).

To add another very interesting angle to the above picture, a skull from Petralona in Greece does not yet have an established date to everyone's satisfaction. When Aris Poulanos (after many years of work in that and other areas)

gave it a date of 700,000 years (Poulanos, 1981, pp. 287–288) there was no great support for such a view. The skull may have been seen to be too advanced for this date for the good of the theory of evolution, though of course, not for creation. If we are to view this to be case then to have skulls like Steinheim, Swanscombe, or the skulls from Spain at 700,000 years; or for these skulls even up to 600,000 years would be unwelcome. To discover *sapiens* fossils or their artifacts from 300,000 years to 500,000 years would present insurmountable problems for evolution within this period. Both fossils and their artifacts are up to 400,000 years. With a history, this could very well be brought up to 500,000 years. To discover *sapiens* from 500,000 years to 550,000 years, however, would rule out evolution. In particular if we are to reject the 700,000 year date for the skull from Petralona (which I believe to be a form of *sapiens* anyway from 700,000 years) we would also reject those from Steinheim and Swanscombe from 700,000 years and from 600,000 years. Then evolution would simply have run out of reasonable time within this picture of the fossil record. We await further fossil discoveries with interest.

Homo erectus is dated at 1.8 million years out of Africa (Gore, 1997) and therefore it seems likely that it was dated at least 1.9 million years inside the continent of Africa. That would then place it alongside the time of skulls such as KNMER 1470, which means that no evolution took place within the *erectus* group from about 2 million years. Therefore, we can wonder if any such evolution occurred at all! If *erectus* remains are found at 2.1 or 2.2 million years of age, then that would begin to remove them from any other line such as the less advanced australopithecines. If *erectus* remains were discovered 2.5 million years ago that would deal the final blow because *erectus* would then be fitted in the time frame of the more primitive australopithecines. That would still leave open the question of whether the original men had elongated skulls or heads like our own. Footprints in the Laetolil beds (Leakey and Hay, 1979) dated as being the same time as Lucy could either belong to human beings needing no further evolution or they could belong to australopithecines. The evidence of their ability to walk could have been the result of direct creation or by way of their genetic potential. For further reading of this view see Brown, 1987 and 1996.

In the same item by Aris Poulanos (1981) on p.288 is an amazing discovery. In layers of rock dating between 2,900,000 and 3,300,000 years are both stone and bone tools. These tools had been found in the rib cage of a fossil elephant. There are no records of any remains of *Australopithecus* fossils outside of Africa and so if we take the ages given in the paper and conclude that either *sapiens* or *erectus*

tus used these tools, this would be another devastating blow to the theory of human evolution. These would be at the start of a history for the australopithecines and so the australopithecines would not be able to have given rise to either *sapiens* or *erectus* forms. Even if we moved the dates forward to 2.5 million years or thereabouts, that would still put evolution in trouble because at those dates *sapiens* or *erectus* would be contemporaneous with the best australopithecines. The fact that those most ancient dates have been no longer heard, we can safely conclude that they have been abandoned.

We can only wonder about the large number of times we may have witnessed serious dating problems with the theory of evolution. This is one more demonstration of the fact that evolutionists try to make macroevolution an unfalsifiable theory. I believe it is possible that one day a certain embarrassing fossil will be discovered such that the moving of its age or status will make no significant difference. It will by its very presence prove to be the downfall of the evolutionary theory.

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 Colin Brown
 61 Derby Road, Golborne
 Warrington WA3 3LE
 England UK

Book Review

Seduced by Science by Steven Goldberg
 New York University Press, New York. 1999, 230 pages, \$28

Steven Goldberg is a law professor at Georgetown University, Washington D.C. He is also the son of a physicist and he understands the limitations of science. Goldberg's theme is that religion has trivialized itself by seeking scientific credibility. On some topics the author is entirely correct. For example, he challenges the popularity of medical "prayer tests." Several double-blind tests have shown that heart patients who are prayed for have a better rate of recovery than those who are distinctly *not* prayed for. Goldberg suggests that such tests reduce prayer to just another optional form of medicine. Prayer is certainly effective, but limiting it to a comparative scientific test is an affront to God.

Goldberg also discusses creation science, but his bias shows. His main sources include critics Ronald Numbers, Christopher Tourney and Dorothy Nelkin. He takes the discredited position that religion is limited to the *why* questions, not the *how* or *when* questions of history. Goldberg

does not think science or history details should be sought from Scripture (p.26). And this is from a Jewish scholar who surely knows the Old Testament well.

Goldberg discusses genetic engineering, and also the separation of church and state. His comments on prayer in public schools are pertinent: A mandated law could quickly reduce prayer to innocuous words, or to a mere formula (p. 86).

The author's motive is to elevate religion above the shifting sands of scientific knowledge. *CRSQ* readers would agree, but would caution Goldberg not to neglect the book of Genesis, the foundation of all true religion and science.

Don B. DeYoung
 Grace College
 200 Seminary Drive
 Winona Lake, IN 46590

Letters to the Editor

Strung Out on String Theory

According to an article in the *Los Angeles Times* (November 16, 1999), string theory would “Reshape fundamental notions of space and time, energy and matter, expanding the number of dimensions to 11” (p. A22). The author of the article, *Times* Science Writer K.C. Cole, quotes Nathan Seiberg of the Institute for Advanced Study in Princeton as saying, “I am almost certain that space and time are illusions” (p. A1). Cole goes on to say,

String theory offers a universe bizarre beyond imagining: Under powerful enough magnification, every known particle in the universe would resemble a complex origami folded out of sheets or strings of the three familiar spatial dimensions, plus one dimension of time, plus seven extra dimensions of space (p. A22).

Cole quotes David Gross, director of the Institute for Theoretical Physics at UC Santa Barbara, who said that the idea that space and time might be illusions “is very disturbing. Where are we? When are we?” (p. A22). To this Cole responds,

The almost unfathomable scenario of a universe without space and time in turn calls into question the very connection between cause and effect. If time can break down, how can one event be placed clearly “before” or “after” another? (p. A22)

This “string theory” could make the whole creation/evolution controversy have no meaning. If space and time are but illusions, then evolutionists could claim infinite time for accomplishing evolution. If creationists were to point to fossils that are out of place or in the wrong time sequence, the evolutionist could merely point to the “string theory” for answers.

What does the creationist physicist say to all this? What can any creationist say?

Clifford L. Lillo
22953A Nadine Circle
Torrance, CA 90505

String Theory and Nonsense A Reply to Lillo

Clifford Lillo has pointed out the nonsensical journalism which can result when we try to reduce particle physics into newspaper articles. I will try to the best of my ability, and within the constraints of a short letter, to explain the real situation.

Extra dimensions, over and above the usual four spacetime dimensions, entered physics soon after Einstein’s general theory of relativity was introduced. One

who has studied the mathematics of general relativity notices how beautiful the explanation of gravitational phenomena becomes in this theory. Hence, it is desirable to include the mathematics of electricity and magnetism in the same framework. To achieve this goal, Theodor von Kaluza introduced a fifth dimension into Einstein’s theory in the early 1920’s, and his theory was extended by Oskar Klein in 1926. The mathematics of relativity involves something called the metric tensor, a doubly-subscripted quantity with the subscripts running, say, from one to four. Introducing the fifth dimension means the subscripts run from one to five, and the metric tensor has five times five or 25 components instead of 16. These extra components enable electric and magnetic fields to be included besides the usual gravitational fields. A remarkable result of the Kaluza-Klein theory is that the relativity equations for the extra electric and magnetic field components are completely equivalent to the equations of electricity and magnetism developed by James Clerk Maxwell in the 1800’s.

Physics has grown over the years, and we are striving to find a unified theory to explain all the types of force, now including gravitational, electrical, magnetic, weak nuclear, strong nuclear forces under one umbrella. Modern string theory seeks to find the “vacuum” state that corresponds to the real world. Such a state would reproduce the particle spectrum, masses, and coupling constants of standard particle physics. It would also determine the correct “cosmological constant” and explain the expansion of the universe as a function of time. Specialists in modern superstring theory are at present producing new facets of the theory at a very fast pace, and it is hoped that the unified theory will soon be forthcoming. Meanwhile there remain challenges such as explaining whether or not there is a small probability for proton decay, smaller than present experimental limits.

In recent years the conventional wisdom that claimed that the extra dimensions were all “rolled up” to a very small size, smaller than an elementary particle, has been challenged. I attempt to deal with the meaning of the “rolled up” dimensions in a paper which has been submitted to the *Quarterly* for publication. There are at least three different ways in which the extra dimensions might not be small. One idea is that all the extra dimensions are felt by all of the particles and forces of nature. According to this concept the Large Hadron Collider (LHC) being planned for completion in Europe in a few years will display some new physics that was not originally foreseen. The extra dimensions are not compacted as small as thought (Antoniadis and Pioline, 1999). A second idea is that there may be extra dimensions that are felt only by the

gravitational force (Dienes, Dudas, Gherghetta, and Riotto, 1998), with the other types of force constrained to what is called a "brane." A third idea also has the particles and forces other than gravity confined to a four-dimensional subspace, a "3-brane," but the subspace is within a $(4+n)$ -dimensional spacetime (Randall and Sundrum, 1999a, b; Schewe, 1999), thus there is no "compactification."

I was able to obtain a copy of the *Los Angeles Times* article on the internet (Cole, 1999), since the *Times* happened to be offering free access at the time I went to their web page.

The article does quote a physicist as saying that space and time are illusions. However, it is very difficult to state in words what the mathematics is really describing. Also, in my opinion these new discoveries will not negate basic logic. They may not, in my opinion, necessarily lead to problems for the creationist viewpoint. In fact, in my paper which I mentioned, these ideas are used to explain some radioisotope data in a satisfying fashion.

Eugene Chaffin
405 Tebbblewood Drive
Simpsonville, SC 29680-3030

String Theory Only a Model

It should be remembered that string theory has been developed thus far with zero experimental evidence. It is a *model* of reality, not reality itself. Only God knows whether there are seven dimensions to space, or perhaps seventy times seven.

If subatomic strings are real, they do not alter the history of the earth. A measurable elasticity of time is limited to objects experiencing either relativistic speed or intense gravity. Neither situation exists in our region of space.

For a half-century, relativity theory and experiments have shown that time can be slightly stretched or contracted. This variation is always sufficiently small to not af-

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fect the human passage of time. Although science fiction runs wild with the idea of time travel, the Creator has clearly protected us from macroscopic time variation. In a similar way, we are spared from noticing the stroboscopic, microscopic world of quantum mechanics.

Creationists have a special interest in cosmic string theory. It is yet another possible layer of created complexity, but certainly not the ultimate building block of nature. This side of heaven, in spite of scientific pronouncements, we are not about to correctly determine the *theory of everything*.

Don DeYoung

The Present Position of Birds and Feathered Dinosaurs

In terms of fossil discoveries, China seems certainly the place to be these days. Discoveries of birds and feathered dinosaurs which were dated at 140 myrs and now are dated at 124 myrs are being it seems continually discovered. *Liaoningornis* is a bird that possessed a well developed sternum and a keel which is the oldest known keel found in a true bird. It also had a capacious and strengthened ribcage, all of which implies the existence of air sacs. This creature also had teeth and it is said a primitive jaw (Shipman, 1997). *Con fuciusornis* differed significantly from its con-

temporary *Liaoningornis*. *Con fuciusornis* had no keel, but did have the oldest known bill and it also had feathers and fused tail bones known as the pygostyle and each foot had a backward pointing toe and curved claws for perching (Haihou, Xhou, Martin and Feduccia, 1995).

From about the same age if not older come two other bird fossils with a number of modern features including the ability to fly up from the ground. One is called *Sinornis* (Serenio and Rao, 1992) and the other is called *Cathayornis* (Zhou, Jin, Zhang, 1992). Moving away from

China for a moment to Spain, we have a young bird caught in amber and dated at 135 myrs which *has* modern wings and its bones had microscopic pits like those of modern juvenile birds and is the oldest known nesting bird, which although not mentioned it is likely to have had a keel for flight which if so would go one better than *Liaoningornis* in being the oldest bird to possess a keel (Ackerman, 1998). Also from Spain mentioned by Shipman in the same item is a sparrow-sized bird from Cuenca province dated between 120 myrs to 130 myrs old. *Eolulavis* from Las Hoyas in central Spain is dated at 115 myrs old. This bird had a sternum and keel and many other modern features, but also had claws on its wings. Its size was that of a goldfinch.

In returning to China we now encounter the feathered dinosaurs. Most if not all of these following creatures have feathers but are not in a fit state for flight and have for the most part features that are purely dinosaurian. They are *Protarchaeopteryx* and *Caudipteryx* (see references section for this under N. China Dinos and Brown, 1999). There is an even more recent discovery which it is said shows some avian-like features, but we must wait and see before we make any hurried opinions. The name given to this one is *Archaeoraptor liaoningensis* (Sloan, 1999). As things stand, the overall facts are more in line with what I have called the shared themes model (Brown, 1996). In this view God either created all the features mentioned in these creatures or He created some of them while others came about by way of the organism's genetic potential. The birds mentioned here are so different in their collective features from each other and most certainly from the feathered dinosaurs that any direct connections is just not possible and their ages for the most part are all too close together for comfort to make any sense of their relationship. There is one other thing which many have tried to forget and bury and this is the fossil of what some have called *Protoavis*. This fossil was dated at 225 myrs old. This is some 78 myrs before *Archaeopteryx* and before all or most of the dinosaurs favored by paleontologists of going into *Archaeopteryx*. This creature has been said by some to possess a

number of advanced avian features one of which is a keel which implies it could fly (Brown, 1987). If this fossil proves true it would spell much trouble if not the end of the dinosaur-bird connection. We await further discoveries from China and elsewhere, but at the moment, the way things stand, the shared themes model stands in good stead.

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Colin Brown
 61 Derby Road, Golborne
 Warrington WA3 3LE
 England, U. K.

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Appearance

Manuscripts shall be computer-printed (or typed) and double-spaced. If you are unable to provide a copy of your paper on computer disk, one final paper copy should have no handwritten marks of any kind in the text area, although you may write page numbers at the very bottom of each page.

Although it is nicer to be positive, there seem to be a lot of important negatives:

- Do not indent the first word of each paragraph; separate paragraphs by an extra blank line instead.
- Never press the space bar more than once anywhere, not even at the ends of sentences.
- Do not hyphenate words at the ends of lines.
- Do not use all capital letters for anything (titles, etc.).
- Do not use bold type in the text; use italics to call attention to words.
- Do not use multiple spaces for tables and similar material. Use tabs instead.
- Do not use dashes, for definitions, but use colons instead, e.g., "NR: Not recorded."

Each footnote should be included *in the text*, surrounded by [brackets], immediately after the text to which the footnote applies.

All references (bibliography) should be presented in the style shown in a recent issue of the *Quarterly*. Additional references from the same author(s) should be preceded by three underline characters in place of the name(s). If a prospective author is not familiar with the *Quarterly* format, the editor will furnish an example reference page.

Book review headings, like references, have a particular style which should be followed. Recent issues of the *Quarterly* will provide examples.

All figures and drawings must be of high quality, therefore, no sloppy hand drawings or freehand lettering will be accepted. The editor reserves the right to approve submitted figures. Unacceptable illustrations will result in rejection of the manuscript for publication. Photographs must be prints rather than slides. Do not embed pictures in text files.

Length

Manuscripts containing more than 25 pages are discouraged. If a topic cannot be covered to the author's satisfaction in this number of pages, the author should divide his material into separate papers that can be serialized in the *Quarterly*. Book reviews should be limited to 1000 words or fewer.

Creation Research Society

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Creation Research Society

History—The Creation Research Society was organized in 1963, with Dr. Walter E. Lammerts as first president and editor of a quarterly publication. Initially started as an informal committee of 10 scientists, it has grown rapidly, evidently filling a need for an association devoted to research and publication in the field of scientific creation, with a current membership of over 600 voting members (graduate degrees in science) and about 1000 non-voting members. The *Creation Research Society Quarterly* has been gradually enlarged and improved and now is recognized as the outstanding publication in the field. In 1996 the CRSQ was joined by the newsletter *Creation Matters* as a source of information of interest to creationists.

Activities—The society is solely a research and publication society. It does not hold meetings or engage in other promotional activities, and has no affiliation with any other scientific or religious organizations. Its members conduct research on problems related to its purposes, and a research fund is maintained to assist in such projects. Contributions to the research fund for these purposes are tax deductible. As part of its vigorous research and field study programs, the Society operates The Van Andel Creation Research Center in Chino Valley, Arizona.

Membership—Voting membership is limited to scientists who have at least an earned graduate degree in a natural or applied science and subscribe to the Statement of Belief. Sustaining membership is available for those who do not meet the academic criterion for voting membership, but do subscribe to the Statement of Belief.

Statement of Belief—Members of the Creation Research Society, which include research scientists representing various fields of scientific inquiry, are committed to full belief in the Biblical record of creation and early history, and thus to a concept of dynamic special creation (as opposed to evolution) both of the universe and the earth with its complexity of living forms. We propose to re-evaluate science from this viewpoint, and since 1964 have published a quarterly of research articles in this field. All members of the Society subscribe to the following statement of belief:

1. The Bible is the written Word of God, and because it is inspired throughout, all its assertions are historically and scientifically true in all the original autographs. To the student of nature this means that the account of origins in Genesis is a factual presentation of simple historical truths.

2. All basic types of living things, including humans, were made by direct creative acts of God during the Creation Week described in Genesis. Whatever biological changes have occurred since Creation Week have accomplished only changes within the original created kinds.

3. The Great Flood described in Genesis, commonly referred to as the Noachian Flood, was a historical event worldwide in its extent and effect.

4. We are an organization of Christian men and women of science who accept Jesus Christ as our Lord and Savior. The act of the special creation of Adam and Eve as one man and woman and their subsequent fall into sin is the basis for our belief in the necessity of a Savior for all people. Therefore, salvation can come only through accepting Jesus Christ as our Savior.