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SPECIAL ISSUE

Astronomy

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- *The Challenges of Extrasolar Planets*
- *Have Creationists Overlooked Biblical Cosmological Data?*
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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

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Editorial

A Special Issue on Astronomy

This is our third spring issue in a row that has a theme. Our previous two special issues were on the iDINO project (Spring 2015) and genetics (Spring 2016). Those topics were biology related, but this issue takes a decidedly different turn to focus on astronomy. Besides a change in topics, this issue is broader in that it has articles from different areas of astronomy rather than a single specialized area.

A Review of Articles in This Issue

The first article is one that I wrote on aliens. There has been relatively little written on aliens in the more technical creation literature. I point out that most creationists think there is no life like us on other planets and that even non-intelligent life probably does not exist elsewhere. On the other hand, evolutionists are nearly obligated to believe that life, and even intelligent life, must be common in the cosmos. Therefore, the creation and evolution models make very different predictions about the possibility of life elsewhere. How do these predictions fare? I show that there are three lines of evidence that confirm the creation-model prediction.

In the second paper, Craig Davis provides a discussion of tidal interactions in the solar system. This is an important topic for the origin issue, because tidal interactions have been invoked in many situations relevant to the age of the solar system. One example is the source of internal heat inside some satellites of the Jovian planets. Tidal interaction may an important factor in another question I have wondered about for some time—synchronous rotation. Most satellites, including the earth's moon, rotate synchronously, so this could be viewed as a common trait of satellites. But what is the origin of this? Most astronomers think it is tidal locking. But tidal locking takes a long time, much longer than the creation model would allow. If that is the case, then might synchronous rotation be a result of design or purpose rather than tidal locking? If so, what might that design or purpose be?

Wayne Spencer writes about extrasolar planets in our third article. Wayne is no stranger to this topic, as he has written more on extrasolar planets than any other creationist. This field is rapidly changing, so it is good that we receive a periodic update on the status of those changes. The data on the more than 3,500 known extrasolar planets are a key part of my argument that we are alone in the universe.

Jake Hebert writes about cosmology in our fourth article. More specifically, Jake concentrates on biblical constraints on developing a biblical cosmology. In the past two years, my own writings on this subject have sparked some discussion between Jake and me. In some respects, I think some of our disagreements may have been what prompted Jake to write his article. This is good. It helps get our discussion out in front of others, which in turn may stimulate the thinking of more people. Such a debate is an important step as we attempt to build a creation model of astronomy, something that doesn't yet exist.

Speaking of cosmology, our final article is Russ Humphreys's discussion of a biblical basis for time dilation. As most readers of the *Quarterly* know, Russ has written on this subject many times. His paper in this issue expands upon his earlier work and is sure to be a good supplement to his previous publications.

Controversy Within the *Quarterly*

Unrelated to astronomy, we have several letters to the editor in this issue. Many of these letters are in response to articles recently published in the *Quarterly*. When we accepted some of these articles, I knew they would be controversial, so it is my pleasure to print these letters, along with responses from the authors of the original articles. It is not that the Society wants to promote controversy. Rather, in the process of building creation models, we inevitably will have disagreements. It is essential that we have a spirited, but friendly, discussion of these differences.

This brings me to another point. It is not my job as editor or that of my assistant editors and the reviewers we use to enforce a single viewpoint. Rather, our job is threefold. First, we must ensure that articles we publish fit within the bounds of the creation model as defined by the purpose of the Society and as instructed by the Board of Directors. Second, articles must properly present evidence and provide good, cogent arguments to reach sound conclusions. Third, the quality of the work presented must be of a certain minimum standard. We regularly reject submissions for failure to meet one or more of these standards (we reject far more articles than we accept). Consequently, as editor, and prior to that as a reviewer, I have approved publication of articles that I disagreed with on many points. That is true of this issue of the *Quarterly* as well. It is important that ideas we disagree with get a good hearing.

Going a Little Further

Since there is some discussion in this issue dealing with cosmology, I want to take the opportunity in my editorial to share something with the general creation community that I have given thought to over the years.

A black hole is defined as a region of space that has such strong gravity that light itself cannot escape from it. Escape velocity is the speed an object requires to be freed of the gravity of a massive body, such as a planet or star. In Newtonian physics, the escape velocity, v_e, is given by

$$v_e = \sqrt{\frac{2GM}{R}}$$

where G is the gravitational constant, M is the mass of the gravitating body, and R is the radius of the gravitating body. One can approximate the escape velocity of a black hole using this equation. Setting the escape velocity to c, the speed of light,

$$c = \sqrt{\frac{2GM}{R}}$$

If ρ is the average density, then mass can be expressed as

$$M = \rho \frac{4}{3} \pi R^3$$

Combining these two equations, we get

$$R = \frac{c}{\sqrt{\frac{8}{3}\pi\rho G}}$$

Using current estimates of the average density of the universe, one can determine what the size (the Schwarzschild radius) of a black hole having the mass of the universe would be. The result is 19 billion light years, suspiciously close to the radius of the observable universe. Given the uncertainty in the density of the universe, it appears the observable universe may be a black hole. What does this mean? I encountered this in a graduate class I took more than 35 years ago. There wasn't much said at the time, except that it was an interesting result. I suspect that most astronomers and cosmologists, if they know of this result, don't know what it means.

By inspection of the second equation, one can see that the mass of a black hole is directly proportional to its radius. Inspection of the fourth equation reveals that the density of a black hole is inversely proportional to the square of its radius. Therefore, the density of a black hole is inversely proportional to the square of its mass. This is counterintuitive, because it means more massive black holes are less dense. Taking this further, for a reasonably uniform mass distribution, mass is directly proportional to the cube of the radius. Other than the origin, the two curves R µ M and R µ M^3 intersect in only one place. Why does the universe exist so that at the very least the radius of the universe is very close to this point of intersection?

One committed to the big bang might argue that in a very old big-bang universe, the universe naturally saturates to this situation. As the universe expands, its density decreases while the size of the observable universe expands in a complex way. Alternately, one might argue that in a big-bang universe it must appear this way. After all, light cannot escape a black hole, and neither can light escape the universe. Ergo, we always appear to be at the center of a black hole. But in a big-bang cosmology, the observable universe is a subset of the much larger universe. If the universe is homogeneous (an assumption upon which all modern cosmology is based), then this must be true at any location in the universe. But this would mean that at any location in the universe, one can draw an event horizon having a Schwarzschild radius in light-years equal to the age of the universe. Since any event horizon arbitrarily can be drawn at every location in the universe, event horizons on this scale are detached from the very matter that necessitated them in the first place. Can event horizons be drawn in this way? I don't think so, but perhaps I'm wrong about that. At any rate, as I already mentioned, there probably isn't an agreed-upon answer to what this result means.

A Possible Creationary Interpretation

Of course, recent creationists reject the big-bang model, so how might we interpret this curious result? Increasingly, recent creationists have come to embrace a form of geocentrism, or, as some prefer to call it, galactocentrism. This is different from the classical geocentric models of Ptolemy or Tycho, where the earth remains motionless with the universe orbiting it. Instead, the earth orbits the sun, and the sun

orbits within the Milky Way galaxy, and the galaxy has motion within the universe, but the earth's location (as well as the sun's and galaxy's locations) lies near the center of a finite, bound universe. Given the vast size of the universe and our relatively modest change in position since creation, to a very good approximation the earth is at the center of the universe. In this model, the universe is bound with an edge. In some versions, there is water beyond the edge (Genesis 1:6–8). But this curious result, that the universe is a black hole, suggests that the observable universe is the universe. That is, there is nothing outside the observable universe that even remotely resembles what is inside.

Some may object that we observe black holes within the universe, such as stellar-sized black holes and supermassive black holes in galactic centers. But this isn't a difficulty, because why can't the black hole of the universe contain smaller black holes? It reminds me of a humorous poem included in Augustus De Morgan's 1872 book, *A Budget of Paradoxes*:

Great fleas have little fleas upon their backs to bite 'em,
And little fleas have lesser fleas, and so ad infinitum.
And the great fleas themselves, in turn, have greater fleas to go on;
While these again have greater still, and greater still, and so on.

I'm not saying this curious little result definitely tells us the universe is a black hole. But I do find it consistent with the cosmology that I have recently pursued. I give it to you, the creation science public, as food for thought.

Danny R. Faulkner
Editor
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Does Extraterrestrial Life Exist?

Danny R. Faulkner

Abstract

Evolutionary models and biblical creation models make very different predictions about the likelihood of life, and especially intelligent life, elsewhere in the universe. Evolutionary models generally predict that life, and probably intelligent life, is relatively common in the universe, while creation models generally predict that we are alone in the universe. Three lines of evidence—the Fermi paradox, SETI, and the search for extrasolar planets—provide evidence to reach a conclusion on the matter. The evidence thus far greatly favors the creationary prediction and contradicts the evolutionary prediction.

Introduction

Extraterrestrials (ETs) are life-forms that exist outside of the earth. While the term ET could apply to any living things elsewhere, in most contexts it refers to intelligent creatures, creatures capable of developing civilization, technology, and eventually space travel. Furthermore, it generally is understood that any ETs are physical beings, not spirit beings, such as angels or demons. In other words, ETs are beings that are in many respects like humans. It is in this context that I will discuss ETs in this paper. It is almost certain that life can exist only on planets, and that the clear majority of planets are not suitable for life. Hence, there has been much discussion as to what conditions a planet must have for it to sustain life.

It is easy to think that discussion of ETs in entirely modern, but that is not the case. Once the geocentric model was discarded in favor of the heliocentric model nearly four centuries ago, the debate of the plurality of worlds picked up. The plurality of worlds refers to the belief that there are other planets on which life might exist and hence would be like our world. Within the geocentric model, the plurality of worlds was not possible, because if the earth was at the center of the universe, there could be no other worlds truly like this one. But once people realized the earth was one of several planets that orbited the sun, those worlds held out at least the possibility that some planets could be like the earth and thus might harbor life. On the heels of acceptance of the heliocentric theory, most people came to realize that the sun is a star. If the sun is a star, then why could not other stars have orbiting planets as the sun does? And if many stars have orbiting planets, perhaps many of those orbiting planets are home to living things. Therefore, the concept of the plurality of worlds became quite a subject of debate.

One of the first people publicly to discuss plurality of worlds was Giordano Bruno in the late sixteenth century. Bruno was an early adherent of the heliocentric theory, and he understood the possible implications very quickly. Bruno opined that many of the planets of the solar system were inhabited, as well as many of the planets orbiting most stars. The Roman Catholic Church burned Bruno at the stake in 1600, and many people today mistakenly cite him as a martyr for science, supposedly because his cosmology and belief in the plurality of worlds ran afoul of religious authorities. However, it was Bruno's heretical *religious* beliefs that got him into trouble with the inquisition, not his cosmological musings (Bergmann, 2014).

In 1632, a few decades after Bruno's execution, Galileo published his *Dia-*

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logo Sopra i Due Massimi Sistemi del Mondo (*Dialogues Concerning the Two Chief World Systems*), in which he argued for the heliocentric theory. This book was called a dialogue, because it was written as a discussion between three participants over four days. Galileo focused on differences between the Ptolemaic (geocentric) model and the heliocentric model, and so he omitted any discussion of life on other worlds. Indeed, if Galileo had any opinions on the plurality of worlds, he kept them to himself. A few decades later, in 1686, Bernard Le Bovier de Fontenelle published *Entretiens sur la Pluralité des Mondes* (*Conversations on the Plurality of Worlds*). As with Galileo's book, this book was in the form of a series of conversations, but this time with two people, not three. Another difference with Galileo's *Dialogues* is that Fontenelle's book presented mostly a case for the heliocentric theory without arguments against the geocentric theory. Furthermore, it included explicit mention of the possibility of life on other planets.

Throughout the eighteenth century, interest in the plurality of worlds continued to increase. For instance, on April 25, 1756, future American president John Adams wrote in his diary about the plurality of worlds. He opined that if beings like us existed on other planets, then it would necessitate Jesus Christ having ministered, died, and risen again to atone for the sins of races on countless planets. By the early nineteenth century, the plurality of worlds was much discussed across society. This was the environment in which Joseph Smith grew up, so it is not surprising that the plurality of worlds is central to Mormon cosmology. Many of these discussions contained theological and philosophical arguments, but supposed scientific arguments began to be offered too. For instance, the famous astronomer William Herschel argued for life on other planets, and he believed that even the moon was inhabited. This reflected widespread belief in life on the moon at the time, which undoubtedly helped make the famous Great Moon Hoax of 1835 so believable.

Throughout the nineteenth century, several well-known scientists and theologians weighed in on the question of life elsewhere in the universe. Two worthy of mention are Thomas Chalmers, the man who invented the gap theory, and William Whewell of Cambridge, who is responsible for appropriating the word "science" as we understand it in the modern sense (what we call science today previously had been called natural philosophy). Chalmers was of the majority opinion, that there were many inhabited planets. On the other hand, Whewell took the minority position, that intelligent life was unique to earth. He published his thoughts in 1853 in *The Plurality of Worlds: An Essay*. Sir David Brewster, the famous physicist and critic of Darwin, in 1856 published a blistering response to Whewell's book in *More Worlds than One, the Creed of the Philosopher and the Hope of the Christian*. It is interesting that all three of these authors, among many, attempted to answer the question of the plurality of worlds from a biblical perspective.

By the end of the nineteenth century, as science rapidly became influenced by evolutionary thinking, the debate had taken a decidedly more secular turn. The French astronomer Camille Flammarion believed that Mars was inhabited by intelligent beings. Flammarion influenced the American astronomer and agnostic Percival Lowell, who saw a vast network of canals on the surface of Mars. To Lowell, these canals proved that a very advanced civilization existed on Mars. Lowell went on to write a series of popular-level books giving his reasons for belief in intelligent life on Mars. Lowell's work looms large, because it inspired the public, as well as many science fiction authors, such as H. G. Wells and Edgar Rice Burroughs. These collective contributions fueled widespread belief in life on Mars that lasted at least until a half century ago.

While it took the Mariner 4 taking close-up photographs of the Martian surface for the first time in 1965 to drive home the reality of the harshness of the Martian environment, much earlier there were good reasons to realize how hostile to life Mars was. In 1903 the famous evolutionist Alfred Russell Wallace published *Man's Place in the Universe: A Study of the Results of Scientific Research in Relation to the Unity or Plurality of Worlds*, in which he discussed the possibility of life elsewhere in the solar system. Wallace concluded that life could not exist anywhere else in the solar system, because conditions on other solar system bodies would not allow for the existence of liquid water, a necessary ingredient for life. In this book, he only briefly discussed the case for Mars.

In response to Lowell, in 1907 Wallace published *Is Mars Habitable? A Critical Examination of Professor Percival Lowell's Book Mars and Its Canals, with an Alternate Explanation*. The Christian astronomer E. Walter Maunder (who in 1908 published the book, *The Astronomy of the Bible: An Elementary Commentary on the Astronomical References in Holy Scripture*) reached a similar conclusion in his 1913 book, *Are the Planets Inhabited?* Maunder doubted that life existed on Venus, but he held out the slim possibility that it could.

While these writers of a century ago were pessimistic about life elsewhere in the solar system, all of them were optimistic about the existence of life on planets orbiting other stars. Their reasoning was based upon probabilities: even if planets favorable for life were relatively rare, the huge number of stars in the universe and the likelihood that many have orbiting planets implied that there may be many inhabitable planets.

Though usually not overtly admitted, nearly all modern discussion of ETs

has been based upon the assumption of the naturalistic origin and evolution of life. If this is the correct explanation of life on earth, then what would an evolutionist expect about the prospects of life elsewhere in the universe? The overwhelming majority of evolutionists believe that life, even intelligent life, must be common in the universe. Otherwise, if life is unique to the earth, then that makes the earth exceedingly special, which in turn at least hints of creation. Therefore, most evolutionists believe in a form of the mediocrity principle, or as Hermann Bondi termed it, the Copernican principle (though the terms have slightly different contexts). Per this principle, there is nothing particularly favored about the earth—our place in the cosmos, the characteristics of the sun and the solar system, the characteristics of the earth, or the fact that life exists on earth. If the earth is in any way unusual among the planets in the universe, then it is merely a matter of statistics. Statistics being as they are, if there is one planet where life exists, then there likely are other planets where life exists. Given the huge number of planets that likely exist in our galaxy, let alone the universe, according to the mediocrity principle, it is almost certain that life must exist on many other planets.

I should point out that there is a minority viewpoint among evolutionists today that life is exceedingly rare in the universe. Major proponents of this position have been the late Sir Fred Hoyle and Chandra Wickramasinghe. They have argued that the biochemistry of life is so incredibly complex that it is extremely improbable that life would ever have arisen in a universe that is merely 13.8 billion years old. If, on the other hand, as Hoyle and Wickramasinghe thought, the universe is eternal, then it is possible, even very probable, that life would have arisen at least once in the universe. Does that mean the earth is perhaps the one place in the universe where life arose spontaneously? Not necessarily. If life is unique to the earth, that would seem to violate the Copernican principle (Bondi, like Hoyle, supported the steady state theory of the universe, in which the universe is eternal). Therefore, Hoyle and Wickramasinghe propagated the concept of undirected panspermia, that life arose once in the universe and has spread from planet to planet via impacts. The ardor that Hoyle had in arguing for the impossibility of life arising spontaneously may have had more to do with his commitment to an eternal universe than anything else. At any rate, Hoyle's view on the rarity of life in the universe is itself rare among evolutionists today, and hence I will not consider this possibility further.

There is one other minority opinion among evolutionists that suggests that life may be unique to the earth or at least very rare in the cosmos. Ward and Brownlee (2000) defined the rare earth hypothesis, that the earth is quite rare, and hence life in the universe is exceedingly rare. This remains the minority viewpoint, because it violates the mediocrity principle. Rather than suggesting any theistic trapping, the extremely rare conditions present on earth are attributed to an incredibly improbable series of events. Given that the rare earth hypothesis remains a minority position among evolutionists, I will not consider this possibility any further either. I note, however, that if the points raised in this paper ever are acknowledged by the evolutionary mainstream, then many evolutionists likely will adopt the rare earth hypothesis.

Biblical creationists agree with Hoyle about the improbability of life in the universe but obviously for very different reasons. Biblical creationists believe God made all things in six normal days and that God had great purpose and exhibited extraordinary design in all that He made. This contrasts sharply with the belief that life arose solely through natural means. The fact that it is extremely improbable that even a single useful protein could arise spontaneously, let alone the many other necessary parts for even a so-called "simple organism," is a powerful argument in favor of special creation. If creation is the correct explanation of life on earth, then the question of whether God created life elsewhere is a theological one, not a scientific one.

Early in the modern creation movement there was some discussion of the possibility of ETs (Cousins, 1970; Armstrong, 1970; Erpenstein, 1972), but there has been little discussion in the technical creation literature since. Of necessity, I must repeat some of the theological arguments of Armstrong. Erpenstein concentrated on planets of the solar system; and it is abundantly clear now that ETs almost certainly are not present on other planets of the solar system. Both Armstrong and Cousins examined the data as it then existed nearly five decades ago to determine the likelihood of extrasolar planets. The first extrasolar planet was discovered a little more than two decades ago, and there has been a sharp increase in the number of extrasolar planets discovered since. Therefore, the time is right for a new appraisal of the question of ETs.

Did God Create ETs?

There is no biblical passage that directly addresses whether God created ETs. In the absence of a clear positive teaching, some Christians suggest it would be a waste if God did not create intelligent life elsewhere. There are at least 10^{22} stars in the universe. That is a staggering number. Data now suggest that a significant fraction of stars have planets, so it is possible that the number of planets is comparable to the number of stars. If that is the case, then one must wonder what the purpose(s) of all those planets must be. Considering the many wonderful sights in so many places in our own world, how many other remarkable vistas must exist on alien worlds? Surely, it is reasoned, God must have made crea-

tures somewhat like us to enjoy these glorious things. This was the essence of the theological argument put forth in the early and mid-nineteenth century by some Christians, such as Brewster. This amounts to an argument of economy. However, who are we to question God's notion of economy? Humanity occupies only a thin sliver on the surface of the earth. Mankind never will directly explore the overwhelming majority of the earth's volume. What delights exist there that no man will ever contemplate? Caverns do not plumb very deeply into the earth's interior, and many of them hold immense beauty and wonder. Yet man has discovered, and likely will discover, only a tiny fraction of all caves in the earth. By the argument of economy, one must posit that the earth's interior must be populated by intelligent beings. Note that the argument of economy has no biblical passages in its support but merely relies upon the belief of well-intentioned people on how they think the world ought to be.

While the Bible does not tell us whether God made ETs, one may draw inferences from Scripture that offer guidance. It appears from the totality of Scripture that God's attention is principally focused upon mankind. It is not necessary that man be at the physical center of the universe, but God's attention certainly is centered on man. God is infinite, so He certainly could concentrate on more than one race of intelligent beings, but there are other theological considerations. If God created ETs similar to humans (i.e., as moral creatures) on any other planets, then are these ETs sinful? Is there a gulf separating them from communion with God? Do they have eternal destinies either with their Creator or separated from the Creator? If not, then ETs are nothing like humans. But if so, what is the origin of their sinful nature? And did God provide a way of salvation? As for their sinful nature, there are two possibilities. One possibility is that ETs have sinful natures because of Adam's transgression (1 Corinthians 15:20–22). But this same chapter contrasts Adam with Jesus Christ, the last Adam, and His saving work (I Corinthians 15:45). Therefore, if ETs are sinful because of Adam's transgression, then the atoning work of Jesus Christ on Calvary for Adam's race is required to satisfy the demand of God. But to ETs, Adam is the alien. And the atonement provided by Jesus Christ was on an alien world. This clearly does not suffice.

The other possibility is that ETs are sinful, because on each of their worlds there was a primordial being, an alien Adam as it were, who transgressed and caused sin to enter their worlds. If that is the case, then the only way of salvation would be that on each of those worlds Jesus Christ was born, lived a perfect life, sacrificially died, and rose again from the dead. Once His ministry was finished on earth, did Jesus go to another planet to provide a way of salvation for ETs there? Hardly. When Jesus left this world, He went to heaven, to sit at the right hand of His Father (Luke 22:69; Acts 2:33; 7:55; Romans 8:34; Ephesian 1:20; Colossians 3:1; Hebrews 1:3; 8:1; 10:12; 1 Peter 3:22). It appears that Jesus, quite literally, died "once for all" (cf. 1 Peter 3:18).

There is one other possibility, that God created ETs, but they remained sinless creatures. The problem with this is that Romans 8:18–25 indicates that the taint of Adam's sin has affected all of creation. This is the reason the entire creation will be redeemed via destruction and reconstruction of a new heavens and a new earth (Isaiah 65:17; 66:22; 2 Peter 3:10–13; Revelation 21:1). If ETs are sinless, they are living in a world that is contaminated with sin through no fault of their own. If ETs are like mankind in every fundamental respect that makes man human, then ETs must also be morally responsible agents, as man is. But they would be sinless beings living in a sin-tainted world. This is a most difficult situation theologically. Therefore, it does not appear that sinless ETs exist.

Having exhausted all the possibilities, we may conclude biblically there are no ETs. This is in stark contrast with the general evolutionary expectation that ETs likely are to be common in the universe. Therefore, we can view these expectations as predictions: the evolutionary model predicts that ETs exist and are even common in the universe, while the creationary model predicts that ETs do not exist. For a long time, there were no data by to which evaluate these two predictions. However, technological advances in recent decades have produced a wealth of data—data that continues to accumulate. What do these data reveal? I will evaluate three lines of evidence that have bearing on the issue.

The Fermi-Hart Paradox

The Fermi paradox, as this is usually known, resulted from an informal discussion over lunch, probably in 1950 (Jones, 1985). The conversation involved Nobel laureate physicist Enrico Fermi, Emil Konopinski, Edward Teller, and Herbert York. Part of the discussion concerned the existence of ETs, which probably was sparked by the tremendous interest in numerous recent UFO sightings at the time. Fermi noted that if intelligent life is common in the universe, then one might expect that many civilizations are far more advanced than ours, and so they likely have already conquered space. Therefore, one would expect that ETs already would have visited the earth, which they have not done (clearly, Fermi rejected the numerous UFO sightings of the time as evidence of alien visitation). This prompted Fermi to ask the question, "Where is everybody?" Twenty-five years later, Michael Hart (1975) more formally addressed the topic.

There has been much discussion of the Fermi paradox (e.g., Webb, 2015). Most discussions have been attempts

to explain the paradox, even though life probably is common in the universe. One explanation is that the great distances involved in interstellar travel would require a very long time and that ETs would find such long journeys difficult for various reasons. However, this objection overlooks the possibility of breakthroughs in interstellar travel and the use of small robotic probes. It is not necessary that ETs make their existence known by directly visiting the earth, which instead could be done via robotic proxies. Even now, the private Initiative for Interstellar Studies has proposed Project Dragonfly—the use of solar sails to send small, unmanned spacecraft to nearby stars. There also has been discussion of the possibility of von Neumann probes, self-replicating spacecraft that explore space.

Other attempted resolutions to the Fermi paradox posit that humans are among the most advanced civilizations in existence. However, that would violate the heart of the mediocrity principle. Still others suggest that ETs purposefully have avoided the earth.

Some evolutionists have opined that planets like the earth are very rare, and hence ETs also are rare. As previously mentioned, this is out of the mainstream of evolutionary thinking. This amounts to modifying the evolutionary hypothesis in the face of data that contradicts the predictions of that hypothesis. Within the evolutionary mainstream, belief in the uniqueness, or at least the extreme rarity, of humanity is not widely accepted, hence the need to explain the Fermi paradox. Of course, the creationary prediction is that there are no ETs, so in the creationary paradigm, there is no paradox. Rather, the null result known as the Fermi paradox is confirmation of the prediction of the creation model.

SETI

Frank Drake conducted the first Search for Extra-Terrestrial Intelligence (SETI) experiment in 1960. Drake reasoned that by 1960, humans had been broadcasting radio for about four decades. He realized that many of these radio signals inadvertently had been escaping the earth, and thus could be detected by alien civilizations within forty light years of the earth. He further reasoned that we could reverse the process and eavesdrop on alien transmissions. Drake used a radio telescope to search for intelligent signals from two stars, Tau Ceti and Epsilon Eridani. His results were negative. From this modest beginning, SETI has grown significantly. At least two current projects are worthy of note. The Allen Telescope Array (ATA, and named for the prime benefactor, Microsoft cofounder Paul Allen) is a privately funded SETI project at the Hat Creek Radio Observatory in northern California. The ATA consists of forty-two 6.1-meter diameter radio dishes (the original plan called for 350 dishes). With the use of very sophisticated electronics, the signals of all dishes are combined, and the system has the capability of scanning a huge number of frequencies in relatively large parts of the sky. The system has operated for nearly a decade, and during that time, it has followed up and classified more than 200 million signals. None of them appear to be from extraterrestrial intelligent sources. Besides the SETI work, the ATA also does conventional radio astronomy work.

The Search for Extraterrestrial Radio Emissions from Nearby Developed Intelligent Populations (SERENDIP), which started in 1979, takes the opposite approach of ATA. SERENDIP piggybacks on existing conventional astronomy programs operating on radio telescopes. The sophisticated equipment observes at many frequencies while other research programs unrelated to SETI operate. This allows search for faint intelligent signals from various sources in the sky. Over the years, a few interesting signals have been identified, but none have been confirmed as coming from an extraterrestrial intelligent source. SERENDIP continually operates on several large radio telescopes.

Since 1999, SETI@home has allowed home computer users to participate in SETI. Volunteers load the software on their computers and then allow that software to run in the background of their computers, sifting for intelligent signals in the huge volume of data generated by SETI. As with other SETI programs, SETI@home has produced a few interesting signals, but none have been confirmed as arising from alien civilizations. Again, all SETI programs to date have produced negative results, despite the incredibly large amount of data collected thus far. This is consistent with the prediction of the creation model, but it contradicts the prediction of the evolution model.

Extrasolar Planets

Extrasolar planets are planets orbiting other stars. As previously discussed, when most people believed the geocentric theory, the possibility of extrasolar planets was inconceivable. The widespread adoption of the heliocentric model during the seventeenth century changed this. However, until two decades ago, extrasolar planets were hypothetical, for there was yet no data to show that they existed. In the interim, there was much speculation about (and belief in) the existence of many inhabitable worlds. At one time, many people opined that all the planets of the solar system were inhabited, as well as the moon. However, during the twentieth century, many of these speculations were put to rest as we learned just how hostile to life the moon and other planets in the solar system are.

The discovery of extrasolar planets became a reality a little more than two decades ago as technological advancement permitted for the first time detection of planets orbiting other stars. The

primary means of detection have been via subtle Doppler motions induced on stars by their orbiting planets (following Newton's third law of motion) and dimming of stars as their orbiting planets transit them. Spencer (2010) has briefly described these techniques. The transit technique received a major boon with the launch of the Kepler spacecraft in 2009. At the time of this writing, the number of known extrasolar planets is approaching 4,000, and that number is certain to continue to grow.

How many of these extrasolar planets have conditions that are conducive for life? Liquid water is thought to be essential for life. Hence, life is possible only on a planet on which liquid water exists. Astronomers define the habitable zone as the region around a star where an orbiting planet with an appropriate atmosphere could support liquid water on its surface. The habitable zone is a thin shell: if a planet orbits interior to this shell, the surface temperature of the planet would be too high for liquid water to exist, and if the planet orbits outside of the habitable zone, the surface temperature would be too cold for liquid water to exist. The size of the habitable zone depends upon the temperature and luminosity of the star. For a cooler and fainter star, the habitable zone is very close to the star, while for a hotter and/or brighter star, the habitable zone is much farther from the star. As we shall see, this factor is very important in evaluating the possibility of life on some extrasolar planets.

Any planets that fall well outside of a star's habitable zone certainly are eliminated for consideration as possible harbors for living things. However, a planet simply orbiting in a star's habitable zone is not sufficient to establish that it may be habitable. Very small planets lack sufficient mass for their gravity to sustain an atmosphere favorable for life. For instance, the moon is well within the sun's habitable zone, but it lacks any appreciable atmosphere, so it cannot sustain life[1]. On the other hand, planets that have very large mass have the opposite problem—their gravity is so strong that they hold onto many gases that are not conducive to life. Many of the extrasolar planets found so far are very massive—often comparable to Neptune or Jupiter; and many others, termed "super Jupiters," are far more massive. These planets likely lack solid surfaces and are not considered habitable, even if they are in the habitable zones of their stars.

Evaluating whether a more modest extrasolar planet (closer in size to the earth) orbiting in the habitable zone of a star is indeed habitable requires knowing the planet's diameter and its mass. We know the masses of the planets discovered via Doppler motion, but we generally do not know their diameters. On the other hand, we know the diameters, but not the masses, of extrasolar planets discovered with the transit method. Knowing either the mass or diameter, one can infer the other by assuming some average density. More typical, one may consider a range of densities and hence infer a range in the unknown quantity. Claims of the discovery of Earth-like extrasolar planets depend upon the assumption of density, so there is tremendous uncertainty in these claims.

Astronomers recognize that the overwhelming majority of extrasolar planets are not hospitable to life. From time-to-time, one hears of the discovery of an earth-like planet orbiting in a star's habitable zone, where life might possibly exist. The first such announcement came in 2007 with the discovery of Gliese 581 d, the first extrasolar planet with a size similar to Earth's known to exist within a star's habitable zone. Gliese 581 d is nearly seven times the mass of the earth (it is dubbed a "super earth"). Since we do not know its diameter, its composition could be more like that of the Jovian (Jupiter-like) planets, which would be problematic for life. But there are additional difficulties. The habitable zone around Gliese 581 (the star that Gliese 581 d orbits) is so close to the star that it is almost certain that the star's tidal effect has synchronized the planet's rotation and revolution so that one side of the planet perpetually faces the star (Spencer, 2010). This would be very bad for supporting life, because one side of the planet would be very hot all the time, while the other side would be very cold all the time, assuming the planet is even Earth-like to begin with. Faulkner (2010) has identified another major problem: the star Gliese 581 is a BY Draconis-type variable star (its variable star designation is HO Librae). Observations of Gliese 581 over a few decades have revealed that the star varies by about 2%. However, the brightness of BY Draconis-variable stars *can* change by 50%. Because we have observed Gliese 581 for only a few decades, we do not know what its long-term behavior is. A variation in brightness by 2% is bad enough, but if it varies by far more, then the prospects for life on Gliese 581 d are very dim. Of more consequence is the mechanism by which BY Draconis-type variables vary in brightness: large sunspots combined with the rotation of the stars. Large sunspots are accompanied by much chromospheric activity that results in the release of many charged particles. Orbiting so closely to Gliese 581, Gliese 581 d likely is bathed in a tremendous flux of charged particles. This would be very hostile to life directly, but the flux of charged particles also would strip any planet of its atmosphere, again rendering the planet lifeless. Hence, there is no realistic expectation that Gliese 581 d could harbor life. If this were not bad

[1] While technically not a planet because it orbits the earth rather than the sun, the moon is large enough so that if it orbited the sun on its own, it could be classified as a planet.

enough, Gliese 581 d may not even exist (Robertson et al, 2014)!

A recently promoted Earth-like planet is Proxima Centauri b, discovered in the summer of 2016. Proxima Centuari b is the first planet discovered orbiting Proxima Centauri, the closest star to the solar system. Proxima Centauri b was discovered by the Doppler motion method. We do not know the inclination of its orbit, so the mass of Proxima Centauri b is not exactly known. Its minimum mass is 1.27 Earth masses. If the actual mass is close to the minimum mass, then Proxima Centauri's mass is a good fit to Earth. We do not know the diameter of Proxima Centauri b. Assuming a composition and density like that of Earth, the minimum size of Proxima Centauri is 10% larger than Earth's diameter. Of course, Proxima Centauri b could be appreciably larger than the minimum size or mass. Furthermore, we do not know the composition of Proxima Centauri b. It is merely an *assumption* that the composition is similar to Earth's. There is an excellent chance that the composition of Alpha Centauri b is significantly different from that of Earth.

Of much greater concern is the star that this planet orbits. Being a red dwarf, Proxima Centauri is very similar to Gliese 581 in its overall properties, such as size, mass, surface temperature, and luminosity. Like Gliese 581, Alpha Centauri is a variable star, albeit of a different type. Proxima Centauri (also known as V645 Centauri) is a flare star. Flare stars are subject to eruptions on their surfaces similar to solar flares but usually more energetic. The X-ray emissions from Proxima Centauri are believed to be like that of the sun (Wood et al., 2001). As with Gliese 581, Proxima Centauri's habitable zone is very close to the star. Proxima Centauri b orbits its star at 1/20 the distance that Earth orbits the sun. As with Gliese 581 b, Proxima Centauri b probably has synchronous rotation. Assuming X-ray emission comparable to the sun, Proxima Centauri b is bathed in an X-ray flux 400 times greater than Earth is. Furthermore, the flux of charged particles from Proxima Centauri experienced by this planet probably is far greater than on Earth. The charged particle flux (stellar wind) could strip Proxima Centauri b of its atmosphere. These factors do not bode well for life on Proxima Centauri b.

The two examples of supposedly Earth-like extrasolar planets briefly described here are among the best candidates. However, both suffer from considerable problems that seriously undermine their status as Earth-like. Only the rosiest of scenarios could qualify these planets as Earth-like. The stark reality is that out of nearly 4,000 known extrasolar planets, *none* is Earth-like. That is, the data from extrasolar planets thus far strongly suggest that the earth is unique.

Conclusion

I have discussed three lines of evidence that suggest that intelligent life is unique to earth: the Fermi paradox, the null results of various SETI programs, and the lack of Earth-like planets among extrasolar planets. Therefore, proper application of the scientific method leads to the conclusion that intelligent life is unique to the earth. Of the three lines of evidence, the Fermi paradox is the least convincing. This is because there are many explanations of why ETs have not yet visited the earth, or at the very least have not left any evidence of their visitation. Not the least among these explanations is the difficulties of interstellar travel. More convincing is the lack of positive results from SETI programs. Advancements in technology in recent decades have enabled us potentially to detect radio emissions from many possible advanced civilizations. Despite the incredible volume of data collected, not one unambiguous alien transmission has been detected.

Probably the most significant data are those resulting from discovery of extrasolar planets. Out of nearly 4,000 detected planets orbiting other stars, not one planet has been clearly identified where life could exist.

Is it not time that we make the conclusion that life is unique to the earth? One objection to reaching this conclusion almost certainly will be that not all the data are in yet. This is true, but when are the all the data ever available? One always can collect more data, yet this normally does not inhibit us from reaching at least preliminary conclusions. After all, it is the nature of science to change conclusions as new data arrives that contradicts earlier conclusions. Why is there such paralysis in making this justified conclusion now?

The reason for the reluctance to reach this conclusion is that the conclusion is contrary to the worldview of many scientists. Many scientists are so committed to life elsewhere that they cannot accept the data that show otherwise. In their estimation, we must refrain from reaching a conclusion on the matter of extraterrestrial life until data that conforms to their foregone conclusion arrives. The only thing that inhibits reaching such an obvious conclusion is the interference of dogma. It is ironic that creationists frequently are accused of letting our dogma cloud our judgment, yet here is a very good example of how evolutionary dogma prevents most scientists from reaching the proper conclusion.

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Tidal Forces in the Solar System

Craig Davis*

Abstract

Tidal forces are a powerful factor in the development of the solar system. This paper summarizes various tidal effects and categorizes them as either direct or secondary, with secondary effects further categorized as strong or weak. Tidally induced heating, as well as the existence of Roche limits, are direct effects of tidal forces. The tidal acceleration effect, which pushes the moon away from Earth, and the tidal deceleration effect, which pulls the Martian satellite Phobos toward Mars, are weak secondary effects, because they depend on a secondary reaction to tides raised by the gravity of the smaller body on the larger body. The tidal locking/despinning effect, which tends to lock one face of a satellite to its planet, and the tidal circularization effect, which tends to produce circular orbits, are strong secondary effects, because they depend on a secondary reaction to tides raised by the gravity of the larger body on the smaller body. A quantification of some of these tidal forces is provided, and a comparative quantification of other tidal effects is made. Some tidal effects are problematic for an old solar system, while other tidal effects appear to place constraints on creation-based models of a young solar system. Further areas of study are suggested.

Introduction

In 1992, tidal forces caused by Jupiter's gravity tore Comet Shoemaker-Levy 9 into pieces. Two years later, the comet retaliated by smacking into the planet. It was not a unique event. Comet Brooks 2 broke into two pieces within Jupiter's Roche limit in 1886 (Luciuk, 2003). Tidal forces from the sun's gravity may have contributed to the breakup of Comet XIV in 1947, Comet Ikeya-Seki in 1965, Comet West in 1976, and Comet Ison in 2012 (Luciuk, 2003). Hartnett describes data from the ESA/NASA Solar Heliospheric Observatory (SOHO), saying, "The SOHO spacecraft has discovered more than 1000 comets that make close approaches to the Sun. In some instances, the comets' orbits cause them to plunge into the Sun" (Hartnett, 2016). Some of these small sun-grazing comets are thought to be remnants of larger ancient comets torn apart by the sun's tidal force (Sekanina and Chodas, 2012). Figure 1 shows Comet Shoemaker-Levy 9 after it was torn apart and before it hit Jupiter.

Tidal Forces

Tidal forces are caused by the force of gravity. Because the gravitational force between two bodies is a function of the distance between the bodies, the gravitational force on the near side of a body is greater than the gravitational force on the far side, and this produces a tidal force. Figure 2 illustrates a tidal force.

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Figure 1. Comet Shoemaker-Levy 9, which was torn apart by tidal forces before crashing into Jupiter. Photo by the Hubble Space Telescope on May 17, 1994. Photo courtesy of NASA and STScI.

The equation for gravitational force is:

$$F_g = GM_p m_s/d^2 \quad (1)$$

where

- F_g is the gravitational force
- G is the gravitational constant
- M_p is the mass of the primary body
- m_s is the mass of the satellite
- d is the distance between the primary body and the satellite

The equation for tidal force is:

$$F_{tidal} = F_{near} - F_{far} \quad (2)$$

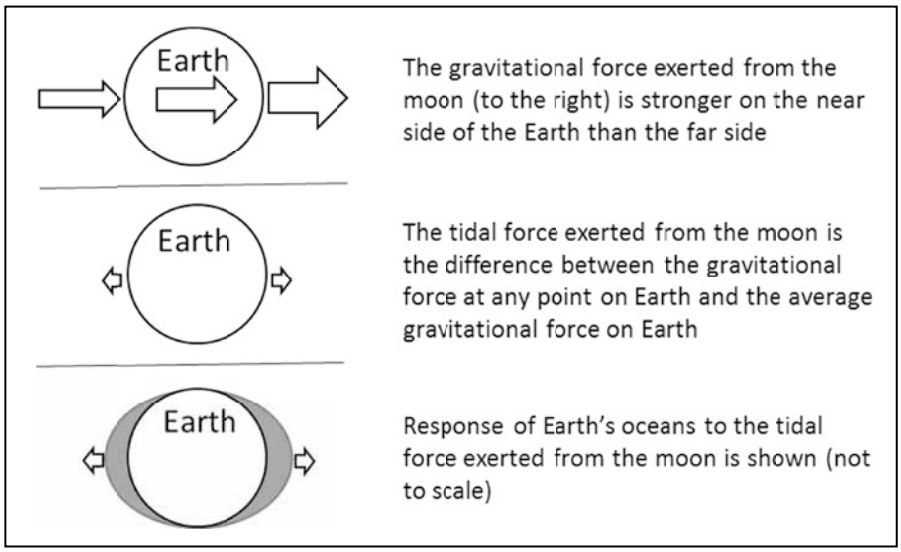

Figure 2. Tidal Forces – Earth/moon example. The moon exerts a gravitational force on Earth, as illustrated by the large arrows in the top drawing. Because it depends on distance, the gravitational force on the near side of Earth is greater than the gravitational force on the far side, producing a residual tidal force, shown by the small arrows on the center drawing. The bottom drawing illustrates how Earth's oceans are raised by the tidal force due to the gravity of the moon.

or

$$F_{tidal} = 2GM_p m_s R_s/d^3 \quad (3)$$

where

- F_{tidal} is the total tidal force acting on the primary body
- R_s is the radius of the satellite body

As equation (1) shows, the gravitational force between two bodies varies based on the distance between the bodies squared, while the tidal force in equation (3) varies based on the distance cubed. Therefore, tidal forces are more sensitive to distance than gravitational forces. Table 1 uses equations (1) and (3) along with well-known physical parameters in the solar system[1] to give a summary of gravitational and tidal forces for the Earth-moon system and for the sun with each planet.

Table 1 shows in a quantifiable form that tidal forces between two bodies are much weaker than the gravitational forces. It also illustrates the sensitivity to

[1] Physical and orbital parameters for bodies in the solar system are from the NASA Jet Propulsion Laboratory Solar System Dynamics web page, ssd.jpl.nasa.gov.

Table 1. Gravitational and Tidal Forces in the Solar System.

	Gravitational Force on Satellite (meters/sec^2)	Tidal Force on Satellite (meters/sec^2)	Gravitational Force on Primary (meters/sec^2)	Tidal Force on Primary (meters/sec^2)
Earth – Moon	2.70E-03	2.44E-05	3.32E-05	1.10E-06
Sun – Mercury	3.96E-02	3.33E-06	6.57E-09	1.58E-10
Sun – Venus	1.13E-02	1.27E-06	2.77E-08	3.57E-10
Sun – Earth	5.93E-03	5.06E-07	1.78E-08	1.66E-10
Sun – Mars	2.56E-03	7.61E-08	8.25E-10	5.03E-12
Sun – Jupiter	2.19E-04	4.03E-08	2.09E-07	3.74E-10
Sun – Saturn	6.50E-05	5.48E-09	1.86E-08	1.81E-11
Sun – Uranus	1.61E-05	2.85E-10	7.01E-10	3.39E-13
Sun – Neptune	6.54E-06	7.19E-11	3.37E-10	1.04E-13

distance for tidal forces, in that although the sun's gravitational force on earth is 180 times greater than the moon's, the moon's tidal force on Earth is twice that of the sun. The gravitational and tidal forces of the planets on the sun are weak. In fact, the moon's gravitational pull on Earth is about 100 times greater than all the planets' gravitational pull on the sun summed together. Their tidal force is much weaker still. For this reason, theories that arise from time to time about the effect of planets lining up, affecting the sunspot cycle or even astrology, should be discounted.

Roche Limits

The comets mentioned in the introduction were torn apart by tidal forces because they crossed within their Roche limit with a larger body. The Roche limit is the distance within which a body, held together only by its own gravity, will disintegrate due to a second body's tidal forces exceeding the first body's gravitational self-attraction (Weisstein, 2007). Comets Shoemaker-Levy 9 and Brooks 2 made the mistake of encroaching within their Roche limit with Jupiter, while comets Ikeya-Seki and Ison entered their Roche limit with the sun.

The equation for the Roche limit between two bodies (Luciuk, 2003) is:

$$d = 2.44R_p(\rho_p/\rho_s)^{1/3} \quad (4)$$

where

- d is the Roche limit distance
- R_p is the radius of the primary body
- ρ_p is the density of the primary body
- ρ_s is the density of the satellite body

The equation indicates that if the density of a satellite and a primary body are the same, the satellite body will reach its Roche limit at a distance of 2.44 times the radius of the primary body. If the satellite body has no tensile strength, it will be torn apart by tidal forces at that distance. This limit is sometimes called the "liquid" Roche limit, since a rigid body within the limit may hold together for some time due to tensile strength. Earth's moon is far beyond its Roche limit, but a number of satellites in the solar system are close to or even within the limit. The Martian satellite Phobos is at a distance of 88%, or within its limit, and ten other satellites in the solar system (Pan, Daphnis, Atlas, Prometheus, Pandora, Cordelia, Ophelia, Naiad, Thalassa, and Despina) are farther inside the Roche limit with their respective planets, in percentage terms, than Phobos. Figure 3 shows the proximity of selected satellites to their Roche limit.

Phobos is slowly moving toward Mars due to tidal deceleration (which will be discussed later). Estimates for the time of Phobos's collision with Mars range from 30–50 million years, with one estimate pegged at 43 million years (Efroimsky and Lainey, 2007). However, as Phobos approaches Mars, the tidal stress will increase, and it may be torn apart by tidal forces before it gets there. Some of the rings around the gas giant planets may be the remains of satellites that disintegrated due to tidal forces within their Roche limits with their planets (Henry, 2008), and the breakup of Phobos may form a ring around Mars. The surface of Phobos already shows "stretch marks," as shown in Figure 4, which may indicate the tidal stress that will one day destroy the satellite (Howell, 2015).

Does the subject of Roche limits have any bearing on the question of the age of the solar system? A 43-million-year time frame for the end of Phobos would

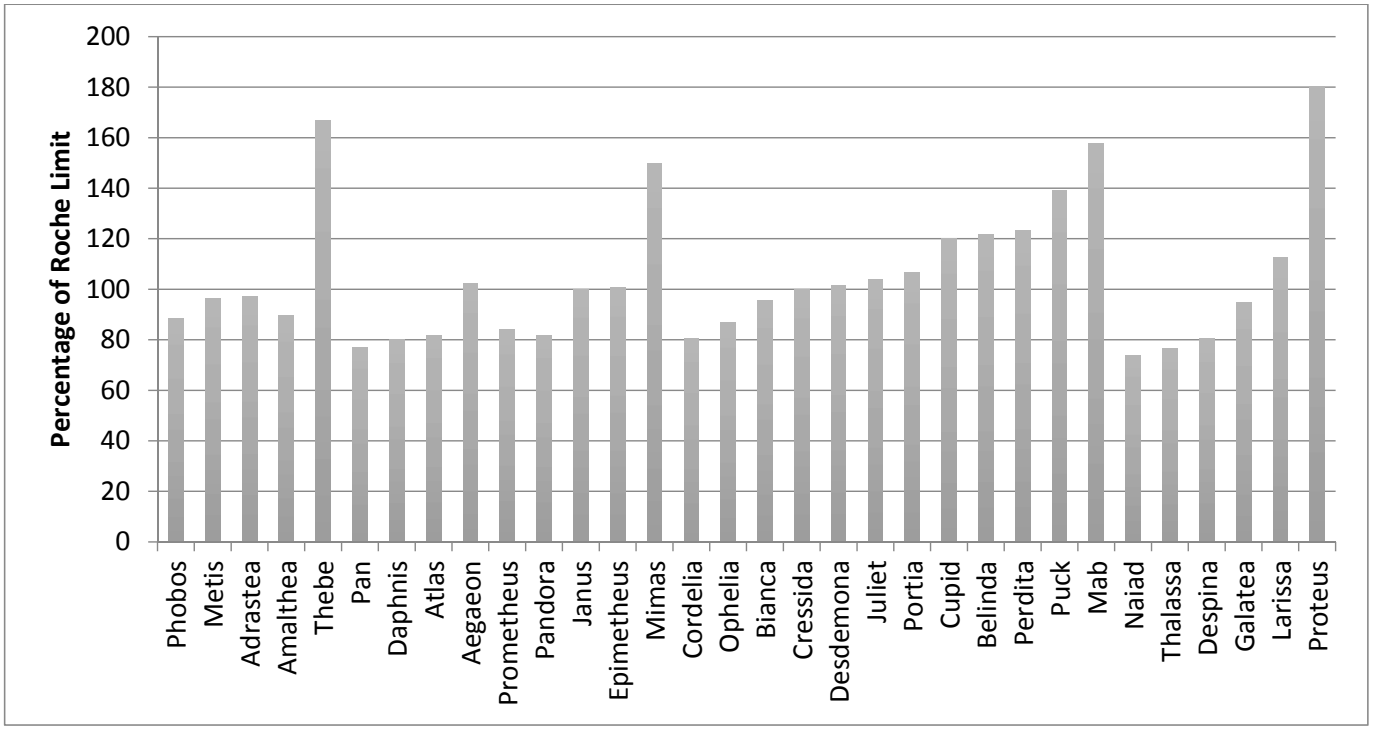

Figure 3. Roche Limits. The chart shows the semimajor axis of satellites as a percentage of their Roche limit. For example, the first satellite shown, Phobos, is at 88% of its Roche limit, so Phobos is within it. All known satellites in the solar system with a value of 200% or less are shown.

be within the last 1% of the age of an old, 4.6-billion-year solar system. If Phobos and the ten satellites farther inside their Roche limit than Phobos were all to break up in the next 43 million years, that would mean that 11 of the solar system's 64 currently known regular satellites would be destroyed during 1% of the solar system's age, which would not seem plausible. However, it is not known whether any of the other ten satellites are decelerating at a significant rate, because neither high-resolution photographs nor measurements of changes in the orbits for the other ten satellites are available yet, so there are no reliable estimates on breakup times for them. The tidal deceleration effect that is moving Phobos closer to Mars is so weak it can scarcely budge any of the other satellites closer to their gas giant planets. Tidal deceleration due to interaction with outer satellites, which will be discussed later, will also not be significant. However, drag can be a factor on satellites close to a planetary body. Drag lowers the orbit of the International Space Station, at an altitude of about 400 km, by 1 km every month or two, depending on variations in Earth's atmosphere. Jupiter's interior satellites Metis, Amalthea, and Thebe show different coloring on their leading and trailing sides, indicating that they are hitting matter as they orbit (Simonella et al., 2000) and encountering some drag. Pan, Daphnis and Atlas are walnut shaped, apparently from gathering material from Saturn's rings and therefore are also encountering drag. Hopefully, future accurate measurements of changes in these orbits will shed more light on the subject.

The continued existence of short-period comets has long been used as an argument for a young solar system, since each time a comet approaches the sun, its ice is heated and some matter is lost (Steidl, 1983). The fact that three comets in the last 25 years have been destroyed by tidal forces, while others discovered by SOHO have plunged into the sun, is anecdotal evidence for another way comets are eliminated and could be factored into the argument.

Secondary Tidal Effects

Tidal forces produce secondary effects, including tidal acceleration, tidal deceleration, tidal circularization, and tidal locking. These effects are secondary in that they first involve the raising of tides on a body due to tidal forces, then those tides act or are acted upon by other gravitational or tidal forces. The secondary application of gravitational or tidal

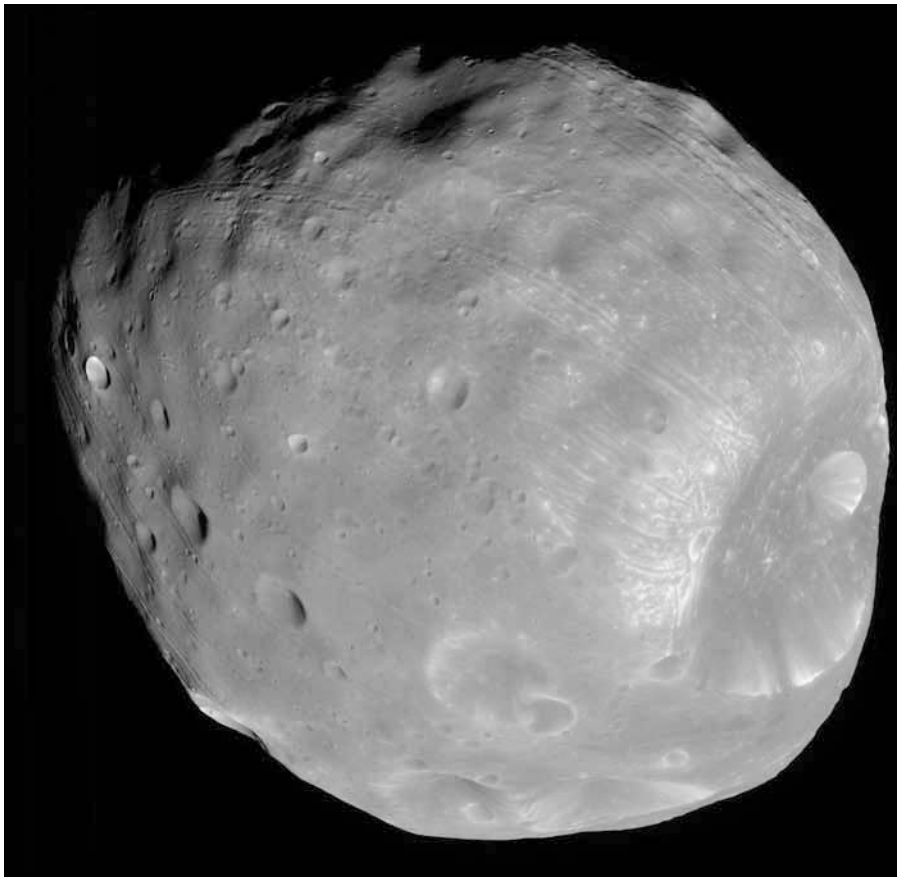

Figure 4. Photo of Phobos taken by NASA's Mars Reconnaissance Orbiter on March 23, 2008. The lines may be stretch marks caused by tidal forces. Photo courtesy of NASA/JPL-Caltech.

forces means that these effects are even more sensitive to distance than direct tidal forces; the strength of the forces between two bodies varies inversely based on the distance between them raised to the fifth or sixth power. Table 2 summarizes the tidal interactions in the solar system.

Tidal Acceleration and Deceleration

A satellite will raise tides on a planet, leading to either tidal acceleration or tidal deceleration of the satellite. (These unfortunate terms can be confusing, since a body that undergoes tidal acceleration ends up moving slower at a higher orbit, while a body that undergoes tidal deceleration ends up moving faster at a lower orbit.) Because tidal acceleration from tides on a planet involves tides raised by the smaller body's gravity on a larger body, tidal acceleration can be considered a *weak* secondary tidal effect.

The best-known example of a satellite raising tides on a planet is on Earth, where the moon causes high and low

Table 2. Possible Tidal Interactions.

Tides Raised on	Tides Raised by	Raises or Lowers Orbit of	Changes Rotation of	Heating Due to Friction	Orbit Eccentricity
planet	satellite	satellite	planet	planet	increases
satellite	planet	neither[6]	satellite	satellite	decreases
satellite	satellite	both[7]	negligible[8]	both	varies
Sun	planet	negligible	negligible	negligible	negligible
Sun	satellite	negligible	negligible	negligible	negligible
planet	Sun	negligible	inner satellites	negligible	negligible
satellite	Sun	negligible	negligible	negligible	negligible

[6] Assuming the satellite is tidally locked and has low eccentricity.

[7] Inner satellites move lower and outer satellites move higher.

[8] The tendency of the planet to tidally despin/lock a satellite will overwhelm the interaction between satellites.

tides on the ocean. High tides typically raise the ocean by about one meter and raise the continental crust by about 30 centimeters (Pogge, 2007). However, because the earth is rotating more rapidly than the moon is orbiting, the highest tides are constantly being rotated a little ahead of a direct line to the moon; the axis of highest tides is not on a straight line to the moon, but about 10 minutes of time ahead of it (Goldreich and Soder, 1966). Because the gravitational pull on the moon is greater from the near side of the planet than from the far side, the advanced tidal bulge accelerates the moon forward a little bit and tends to raise its orbit. The effect is strongest at perigee, the point in the moon's orbit when it is nearest to the planet, so this effect also tends to increase the orbit's eccentricity. The effect, known as tidal acceleration, is illustrated in Figure 5 and applies to any planet-satellite system in which the planet rotates faster than the satellite orbits. Because the total angular momentum in the overall planet-satellite system must be preserved, there is an opposite effect on the planet known as tidal braking, tidal locking, or tidal despinning. Tidal braking slows the rotation of the planet and will be discussed later. Some angular momentum is also lost to friction inside the planet. The effect is analogous to placing a hand on a spinning wheel: the wheel tends to accelerate the hand, the hand tends to brake the wheel, and there is some heat due to friction.

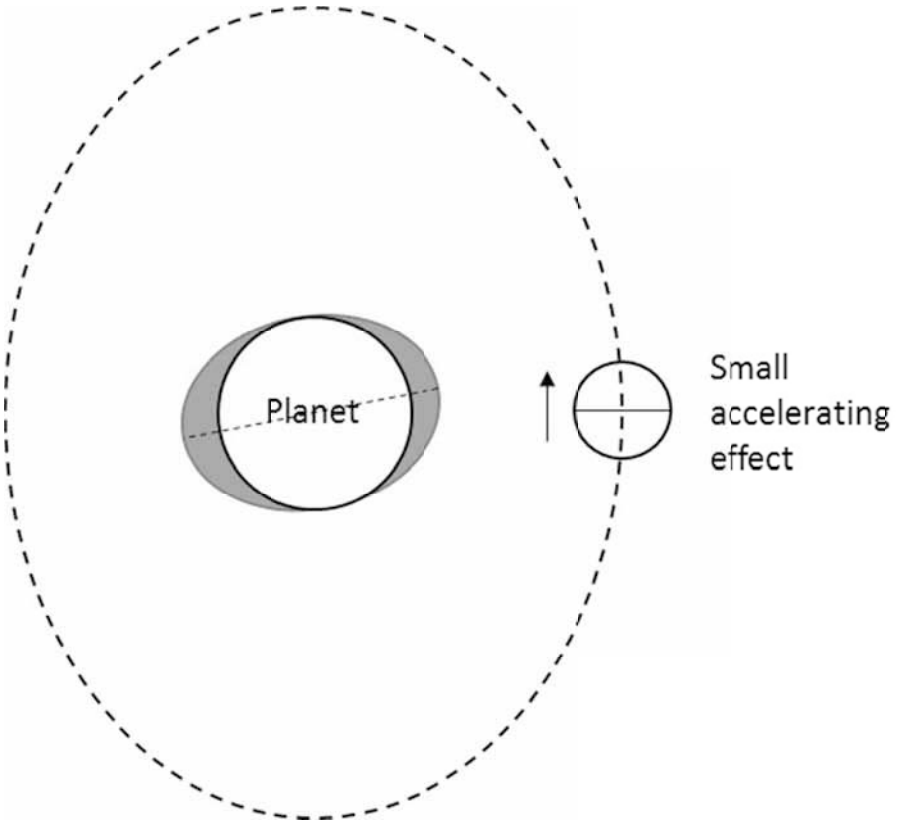

Figure 5. Tidal Acceleration (not to scale). Because the planet rotates faster than the satellite orbits, the tides raised on the planet are rotated a little ahead of a direct line to the satellite. The gravitational pull on the satellite from the near side high tide is greater than the pull from the far side high tide, causing the satellite to accelerate slightly and the planet to slow its rotation slightly.

The current rate at which the moon moves away from Earth has been accurately measured by lunar laser ranging at 38.3 mm per year, or 3.8 meters per century. The lunar perigee is increasing at a rate of 30.4 mm per year, while the apogee is increasing by 46.2 mm per year, illustrating the tendency to increase the orbit's eccentricity (Williams, Boggs, and Ratcliff, 2016). Lisle and others have argued that this lunar recession due to tidal acceleration places an upper bound on the age of the Earth-moon system that is lower than the 4.6 billion years usually assumed for the solar system (Lisle, 2006).

If a satellite is orbiting a planet faster than the planet rotates, the effect is reversed: the satellite is pulled closer to the planet (tidal deceleration), and the planet rotates faster. The effect is analogous to pushing on a spinning wheel to try to make it go faster: the wheel tends to decelerate the hand, and the hand tends to speed up the wheel. There are 19 known satellites in the solar system that orbit very close to their planet such that their orbital rate is faster than their planet's rotation rate. The best studied case, due to its proximity to Earth, is Phobos, the interior satellite of Mars. Phobos completes an orbit of Mars every 7 hours and 39 minutes, while Mars rotates once every 24 hours and 37 minutes. Measurements indicate that the orbit of Phobos is decreasing by 2 meters every 100 years, which will cause its eventual breakup, as discussed earlier (Beatty, 2015).

The Earth-moon system and the Mars-Phobos system are the only instances in the solar system in which changes in a satellite's orbit have been directly measured with a high degree of confidence, although some effort has been made to quantify this effect mathematically. The tidal equation for

Table 3. Tidal Acceleration/Deceleration of Selected Satellites by Equation (6).

Satellite	Tidal Quality Factor Q of Planet[9]	Love Number k_2 of Planet	Current Semi-Major Axis (1000 km)	100 Year Change (meters)
Moon	12	0.302	384.4	3.73
Phobos	99.5	0.164	9.4	-3.50
Deimos	99.5	0.164	23.5	0.004
Io	35600	0.37	421.8	11.2
Europa	35600	0.37	671.1	0.47
Mimas	2453	0.39	185.6	5.13
Enceladus	2453	0.39	238.0	3.76
Tethys	2453	0.39	294.7	6.64
Dione	2453	0.39	377.4	3.02
Rhea	2453	0.39	527.1	1.01
Titan	2453	0.39	1221.9	0.58
Miranda	500	0.104	129.9	2.94
Ariel	500	0.104	190.9	7.27
Umbriel	500	0.104	266.0	1.02

[9] Values of Q and K_2 for Mars, Jupiter, Saturn, and Uranus are taken from Lainey (2016).

change in a satellite's semimajor axis[2] first developed by William Kaula is (Efroimsky and Lainey, 2007):

$$da/dt = -3k_2R^5Gm / Q\,(\mathrm{sqrt}(G(M_0 + m))a^{11/2} \quad (6)$$

where

- da/dt is the change in the semimajor axis of the motion of the satellite around the planet in meters per second
- k_2 is the tidal Love number of the planet, a measure of its rigidity
- R is the radius of the planet
- G is the gravitational constant, 6.674×10^{-11} N·m²/kg²
- m is the mass of the satellite
- Q is the dissipation function of the planet, or tidal quality factor = half the rate at which energy is dissipated through friction
- M_0 is the mass of the planet
- a is the semimajor axis; the distance between the planet and the satellite

Table 3 uses equation (6) to calculate the change in the semimajor axis of selected satellites.

Equation (6) gives a result that roughly matches the measured results for the moon and Phobos, though the given deceleration of Phobos is higher (3.6 meters) than what has been measured (2 meters). Earth's tidal quality factor Q value of 12 is lower than any other planet because of the presence of liquid oceans on the surface, and this is an important factor in the recession of the moon. For other bodies in the solar system, any conclusions should be tentative, since k_2 and Q are not usually well known now and may have changed over time. Also, for gas giant planets, the presence of multiple satellites may introduce other factors that overwhelm the effects of tidal acceleration or deceleration. Jupiter's satellite Io would be moving away from Jupiter at 11 meters per 100 years, but there is reason to believe that is not occurring, perhaps due to Io's resonance with other Jovian satellites (Lainey, 2009).

Based on equation (6), some of the satellites of Saturn and Uranus show significant acceleration. The larger satellites of Saturn inside of Titan (Mimas, Enceladus, Tethys, and Dione) accelerate at rates similar to the moon (5.1, 3.8, 6.6, and 3.0 meters per 100 years, respectively). Because all these satellites are closer to Saturn than the moon is to Earth, they present the same dilemma for an old solar system model as the recession of the moon. "The present quantification of Saturnian tidal dissipation is incompatible with a satellite formation scenario in Saturn's subnebulae for all moons below Titan" (Lainey et al., 2012). In the Uranus system, Ariel and Umbriel, both closer to the planet than the moon is to Earth, move away from the planet at rates of 2.9 and 7.3 meters per 100 years.

The tidal acceleration numbers for the satellites of Saturn and Uranus are large enough to constitute a new argument against an old solar system model. This analysis is new, since until recently, the tidal quality factor Q of the gas giant planets was assumed to be much larger. The assumption was made partly to preserve an old solar system, as Goldreich and Soder write, "For if Q_p were too small, the orbits' evolution would be

[2] The semimajor axis is the average orbital distance.

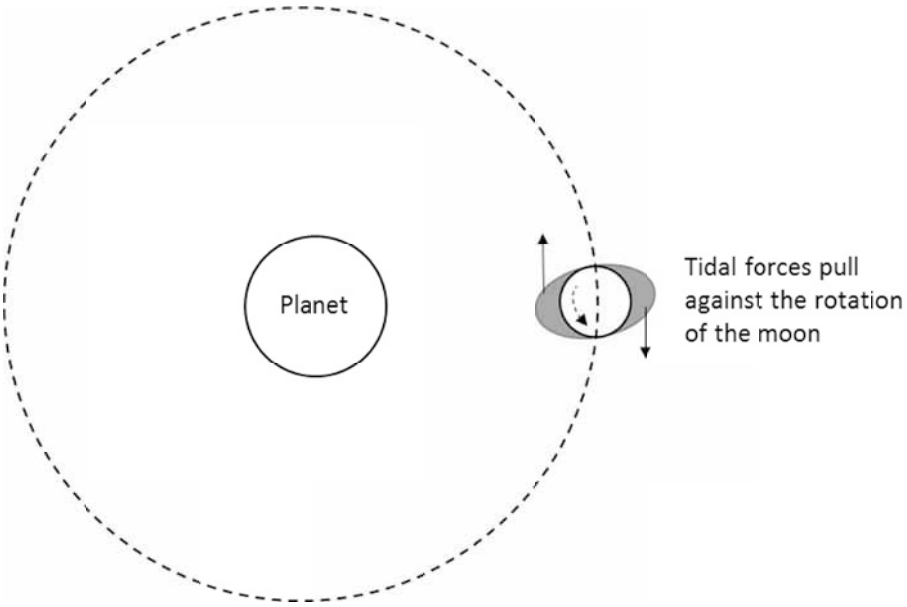

Figure 6. Tidal Locking applies to a satellite that rotates faster than it orbits. The tides raised on the satellite are rotated forward, a little ahead of a direct line to the planet. The planet's gravity pulls forward on the near side high tide and pulls back on the far side high tide, slowing the rotation and eventually locking the satellite into a spin-synchronous orbit in which the same side of the satellite always faces the planet.

too rapid and, tracing them back in time, the satellites would have been at the surface of the planet less than 4.5 X 10^9 years ago" (Goldreich and Soder, 1966). Therefore Goldreich and Soder set Q values for Saturn at 60,000 to 70,000 and for Uranus above 72,000 (Goldreich and Soder, 1966). It is only recently that Lainey and others used measurements from the Cassini spacecraft to calculate a new, much lower Q value (2453) for Saturn (Lainey, 2016). The estimated Q value for Uranus (500) is expected to be substantially refined by future observations (Lainey, 2016).

Tidal Locking

Tidal locking causes the orbital period and rotational period of a body to become equal, thereby locking the same face of a satellite to its planet, as Earth's moon always has the same side facing Earth. This is also called tidal despinning, or tidal braking. Because tidal locking in this portion of the discussion involves tides raised by the larger body's gravity, tidal locking can be considered a *strong* secondary tidal effect. The force for tidal locking is strong enough that it has been used on artificial tethered satellites in a technique known as gravity-gradient stabilization (Fischell, 1964).

Figure 6 illustrates the tidal locking/tidal despinning effect. The planet raises tides on a rotating satellite. Because the satellite is rotating more rapidly than it is orbiting, the highest tides are constantly being rotated a little ahead of a direct line to the planet; the axis of highest tides is not on a straight line to the planet but a little ahead of it. The planet's gravity pulls back on the tidal bulges, slowing down the satellite's rotation. This effect applies to any planet-satellite system in which the satellite rotates faster than it orbits, and to planets with the sun. If a satellite is close enough to a planet so that it orbits faster than it rotates, the effect reverses: the forces work in the opposite direction but still with the end result of locking the satellite to the planet. The effect is analogous to resting a hand on a spinning wheel until it stops spinning.

Because the total angular momentum in the overall planet-satellite system must be preserved, the orbit of the satellite is raised as the satellite despins, until it reaches the point where the satellite is tidally locked to the planet. This increase in the satellite's orbit due to its own tidal locking has not usually been considered in previous treatment of the recession of the moon. For the moon, the increase would be on the order of hundreds (not thousands) of kilometers, marginally strengthening the classic young solar system argument based on lunar recession.

Because the tidal forces are strongest at periapsis and weakest at apoapsis, as the orbit is lifted, the tidal despinning effect tends to increase the eccentricity of the satellite's orbit, though this effect will be very slight.

Tidal locking time can be calculated with this formula (Peale, 1977):

$$t_{lock} = wa^6IQ / 3Gm^2k_2R^5 \qquad (7)$$

where

- w is the initial spin rate expressed in radians per second
- a is the semimajor axis of the motion of the satellite around the planet
- $I = 0.4m_sR^2$ is the moment of inertia of the satellite, where m_s is the mass of the satellite and R is the mean radius of the satellite,
- Q is the dissipation function of the satellite, or tidal quality factor = half the rate at which energy is dissipated through friction.
- G is the gravitational constant, 6.674×10^{-11} N·m^2/kg^2
- m is the mass of the planet

Table 4. Tidal Locking Time Scales of Planets by the Sun.

	Tidal Quality Factor Q[10]	Love Number k_2	Time in Years	Time in Years (Peale, 1977)
Mercury	100	0.451	4.43E+08	2.8E+07
Venus	17	0.295	5.49E+9	2.9E+08
Earth[11]	12	0.302	2.39E+10	1.8E+09
Mars	99.5	0.164	3.25E+12	7.6E+10
Jupiter	35600	0.37	2.59E+17	4.4E+12

[10] Values of Q and k2 are taken from Lainey (2016) and Chen (2013).

[11] The "Time in Years" result for Earth is misleading, since despinning due to the tidal force of the moon will occur five times faster than despinning by the sun.

- k_2 is the tidal Love number of the satellite
- R is the radius of the satellite

All regular satellites[3] in the solar system out through Saturn, except for Saturn's satellite Hyperion, are tidally locked to their planet. Neptune's satellite Triton is tidally locked, and Pluto and Charon are both locked to each other. The satellites of Uranus are presumed to be locked, though this has not been confirmed by observation. No planets are locked to the sun, although Mercury is in a 3:2 spin-synchronous orbit, and Venus rotates very slowly in a retrograde direction. Tables 4 and 5 are illustrative of the time it would take selected planets and satellites to lock to their planet, assuming a theoretical scenario in which the satellites started in their current location and had a rotational period of 12 hours.[4] The times provided in Tables 4 and 5 are dependent on the supplied values of Q and k_2 for the satellites, which are not well known outside the Earth-moon system and may be off by more than an order of magnitude. Also, the initial 12-hour period is only a reasonable guess, and the results are heavily dependent on the distance involved, which may have changed over time. Therefore, the results should be considered illustrative only rather than highly accurate. An alternate set of results (from Peale, 1977) is provided for comparison.

The timescales involved in tidal locking appear problematic all around. Some of the tidal locking timescales, like those for the moon and Saturn's satellite Iapetus, appear to be too long for a young solar system and appear to constrain young solar system models to assume an initial creation with at least some of the regular satellites already in a locked state. The fact that the gas giants spin more quickly than the inner planets could be considered a successful prediction of an old solar system model, since over a long timescale, the sun's tidal locking effect would be significant for the inner planets but negligible from Mars outward. On the other hand, neither Mercury nor Venus is exactly locked to the sun. Since every other body that has locked to its primary is in a 1:1 nearly circular rotation, it is not clear why Mercury would be in an elliptical orbit with a 3:2 spin synchronous rotation nor why Venus should rotate slowly in a retrograde motion. Finally, the fact that Earth spins more quickly than Mars would be unexpected in an old solar system for three reasons: (1) the sun despins Earth more quickly than Mars because Earth is closer, (2) the moon has an even more powerful despinning effect on Earth than the sun does, and (3) Earth has a smaller tidal quality factor "Q" than Mars, which would cause Earth to despin more quickly. The moon's despinning effect would have been stronger in the past when it was closer to Earth and should in fact have slowed Earth's rotation all the way down to a tidally locked state.

Tidal Circularization

Tidal circularization will occur only after tidal locking, since a spinning satellite negates the alignment of the tides described in this section.[5] Because tidal cir-

[3] Regular moons are moons that appear to have their origin connected to the planet they orbit. The solar system also contains irregular moons that appear to not have their origin connected with their planet, but instead appear to have been captured at some later time by the gravity of the planet. Regular moons orbit close to the planet in near-circular orbits near their planet's equator, while irregular moons orbit much farther from their planets, usually with high inclinations and high eccentricity. Neptune's moon Triton stubbornly defies these two obvious categories and would require a treatment all its own.

[4] 12 hours is a rough median for a rotation period of known solar system bodies that are not tidally locked.

[5] The planet Mercury gives an example of a body that is close to but not quite tidally locked to its primary—it has a 3:2 spin-orbit resonance with the sun with a very slow, 58-day rotation period. Despite being nearly locked to the sun, Mercury has the highest eccentricity of any planet, indicating that no significant circularization has occurred.

Table 5. Tidal Locking of Selected Satellites by Planets.

	Tidal Quality Factor Q	Love Number k_2	Time in Years	Time in Years (Peale, 1977)
Moon	37.5	0.02405	2.05E+07	3.2E+06
Phobos	100	0.01	1	880
Deimos	100	0.01	313	9.1E+05
Io	13.6	0.8	26	50
Europa	100	0.25	1180	1200
Ganymede	100	0.6	5210	6600
Callisto	100	0.5	11,750	2.2E+05
Mimas	100	0.1	5.6	140
Titan	100	0.589	1.27E+05	1.9E+05
Hyperion[12]	100	0.1	3.19E+07	9.2E+07
Iapetus	100	0.1	1.13E+10	8.7E+08
Oberon	100	0.1	32993	2.7E+05
Triton	100	0.1	15,100	2000
Charon	100	0.1	21,900	
Pluto (by Charon)	100	0.1	1.77E+06	
Earth (by moon)	12	0.302	5.04E+09	

[12] Hyperion rotates chaotically and is the only regular satellite in the solar system known to be not tidally locked. It is possible that its proximity to and 4:3 resonant orbit with Saturn's large satellite Titan is preventing tidal locking from occurring.

cularization in this discussion involves tides raised by the larger body's gravity, tidal circularization can be considered a *strong* secondary tidal effect.

If a satellite is in an elliptical orbit with its face locked to the planet (like the moon and almost all the regular satellites in the solar system), it must rotate at a uniform rate, but it doesn't orbit around its planet at a uniform rate. Therefore, the tidal bulges move back and forth across the satellite a little. (This flexes the matter in the satellite and can heat the satellite due to friction, as discussed later.)

At periapsis, when the satellite is closest to the planet, the satellite's orbital velocity is at maximum. Here, its rotation begins to lag behind its orbital motion. The near side bulge pulls ahead of the planet, and the far side bulge falls behind. The gravitational pull on the near-side bulge is stronger than the pull on the far-side bulge. Therefore, there is a small backward tug on the near-side bulge, slowing down the satellite's orbital velocity. The rotation catches up with the orbital motion at apoapsis when the satellite is farthest from the planet and then begins to pull ahead. This braking effect at periapsis and acceleration at apoapsis circularizes the orbit. Figure 7 illustrates this effect.

Since none of the planets are tidally locked to the sun, no tidal circularization of the orbits of planets has occurred. Table 6 lists the planets and the eccentricity of their orbits, showing that there is no correlation between their distance from the sun and their orbital eccentricity. In fact, Mercury has the highest eccentricity even though it is closest to the sun. On the other hand, any table of regular satellites in the outer solar system will show lower orbital eccentricities than are present in the planets. As an example, Table 7 shows the eccentricities of the eight interior satellites of Jupiter.

The comparison of the eccentricity of Jupiter's satellites with the sun's planets shows that the satellites as a group have lower eccentricity than the planets (the same pattern is present for satellites of Mars, Jupiter, Saturn, Uranus, and Neptune, though not Earth). Unlike the planets, all these satellites are tidally locked, so tidal circularization may have affected them.

Of all the tidal effects, tidal circularization is the one that is most sensitive to distance. The reason is that in addition to being a secondary effect, a tidally locked satellite has the same rotational period as its orbital period, so if its orbital period is large, its rotation will be slow. The slower a satellite rotates, the weaker the tendency to rotate tides forward becomes. Although the Earth-moon system is undergoing tidal circularization, the one-month rotation period for the moon is so slow that the tidal circularization effect is weaker than the tidal acceleration effect causing the lunar recession, so the moon's orbit is becoming more eccentric rather than circularizing.

Meibom and Mathieu (2004) indicate in a study of binary stars that those with an orbital period of 10 days or less tended to be highly circularized, while those with a longer period were not. Figure 8 shows a plot of the eccentricity of solar system satellites against their orbital period, with results similar to those of Meibom and Mathieu (2004). The conclusion is that tidal circularization has a powerful effect close to a planet, but at distances greater than those involving about a ten-day period, the tidal

circularization effect is ineffective and/or swamped by other factors.

The equation for tidal circularization timescale given by Rasio et al. (1996) is:

$$t = \frac{4}{63} Q \frac{(a^3/GM)^{1/2}}{(m/M)(a/R)^5} \quad (8)$$

where

- t is the time to circularize an orbit
- Q is the dissipation function of the satellite, or tidal quality factor = half the rate at which energy is dissipated through friction
- a is the semimajor axis
- G is the gravitational constant, 6.674×10^{-11} N·m^2/kg^2
- m is the mass of the satellite
- M is the mass of the primary
- R is the radius of the satellite

For most satellites in the solar system, equation (8) gives values too high for a young solar system, indicating that if a satellite initially had an eccentric orbit, the time to circularize the orbit would be greater than the life of the solar system. This places a constraint on young solar system creation models that requires satellites to be created in orbits nearly as circular as they are today. It does not mean that tidal circularization has no effect in a young solar system—some satellites close to their planets would circularize even in a short time frame, and almost all satellites would today be in an orbit more circular than the one in which they were created.

For some bodies in the solar system with a circular orbit, equation (8) produces values too great for even an old solar system. The outer satellites of Pluto (Styx, Nix, Kerberos, and Hydra) are all in a nearly circular orbit, though with orbital periods of 20–38 days. Dysnomia, the satellite of the dwarf planet Eris, has a circular orbit with an orbital period of 15 days. These satellites are rotating in any case, so tidal circularization could not have been a factor in their development.

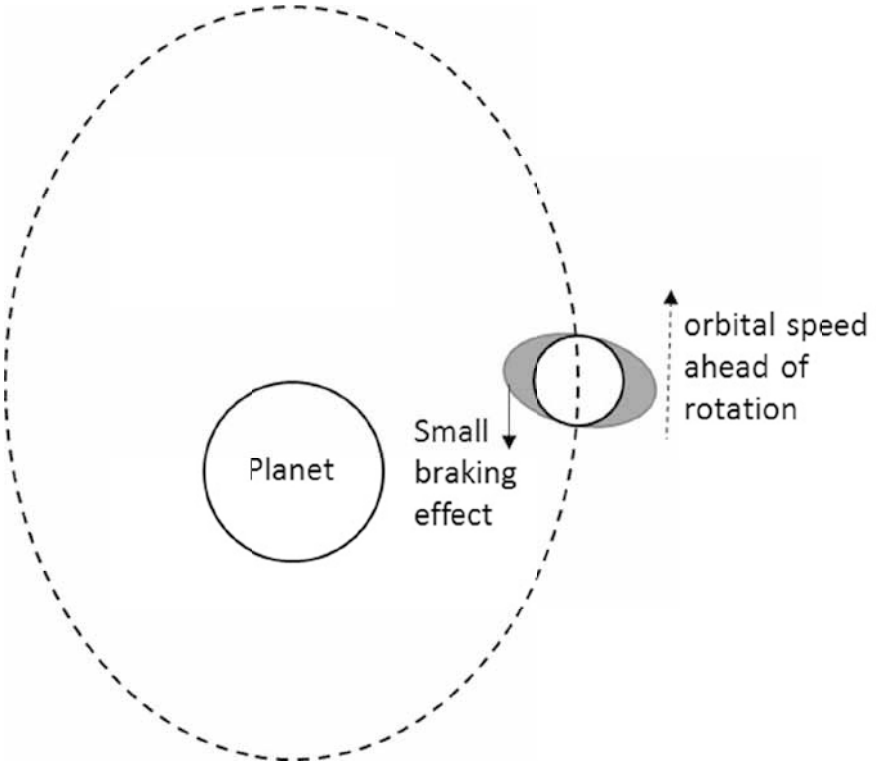

Figure 7. Tidal Circularization applies to a satellite that is already in a spin-synchronous orbit. In an eccentric orbit, the orbital speed varies, but the satellite's rotation is constant. Therefore, the high tides do not always point directly at the planet. When the orbital speed is high and gets ahead of the rotation, the axis of the tides points ahead of the planet. The gravitational force on the near side high tide is greater than the far side high tide, exerting a small braking effect. When the orbital speed is low, the effect is reversed, exerting an accelerating effect, producing a net tendency to circularize the orbit.

Table 6. Orbital Eccentricity of the Planets.

	Distance from the Sun (km)	Eccentricity of Orbit
Mercury	5.79E+7	0.2056
Venus	1.01E+8	0.0068
Earth	1.50E+8	0.0167
Mars	2.28E+8	0.0934
Jupiter	7.78E+9	0.0485
Saturn	1.42E+9	0.0556
Uranus	2.87E+9	0.0464
Neptune	4.50E+9	0.0095

Table 7. Orbital Eccentricity of Jovian Satellites.

	Distance from Jupiter (km)	Eccentricity of Orbit
Metis	1.28E+5	0.0012
Adrastea	1.29 E+5	0.0018
Amalthea	1.81 E+5	0.0032
Thebe	2.22 E+5	0.0176
Io	4.22 E+5	0.0041
Europa	6.71 E+5	0.0094
Ganymede	1.07 E+6	0.0013
Callisto	1.88 E+6	0.0074

The orbits of planets in general are not highly elliptical, though they are not as circular as regular satellites, and tidal circularization could not have been a factor in circularizing the orbits of the planets. Therefore, old solar system models also need to find a reason for circular orbits other than tidal circularization.

Tidal Effects of Multiple Satellites

Multiple satellites orbit the planets Mars, Jupiter, Saturn, Uranus, and Neptune. In addition to the tidal effects between the planets and their satellites, tidal effects between the satellites also exist. These tidal effects are understandably complex and difficult to model mathematically. However, it can be shown that there is a tendency for tidal effects between satellites to decelerate (lower) the lower satellites and accelerate (raise) the higher satellites. "For to the one who has, more will be given, and he will have an abundance, but from the one who has not, even what he has will be taken away" (Matthew 13:12 ESV). The effect is illustrated in Figure 9.

Figure 9 shows a scenario where both satellites are tidally locked to their planet. The inner satellite is orbiting and rotating more rapidly than the outer satellite. Each satellite raises a tidal bulge on the other satellite. As occurs with tides raised on Earth, each satellite rotates its tidal bulge forward, but the inner satellite is rotating more rapidly, so its tidal bulge rotates a little ahead of the tidal bulge on the outer satellite. In the configuration shown in Figure 9, with both satellites on the same side of

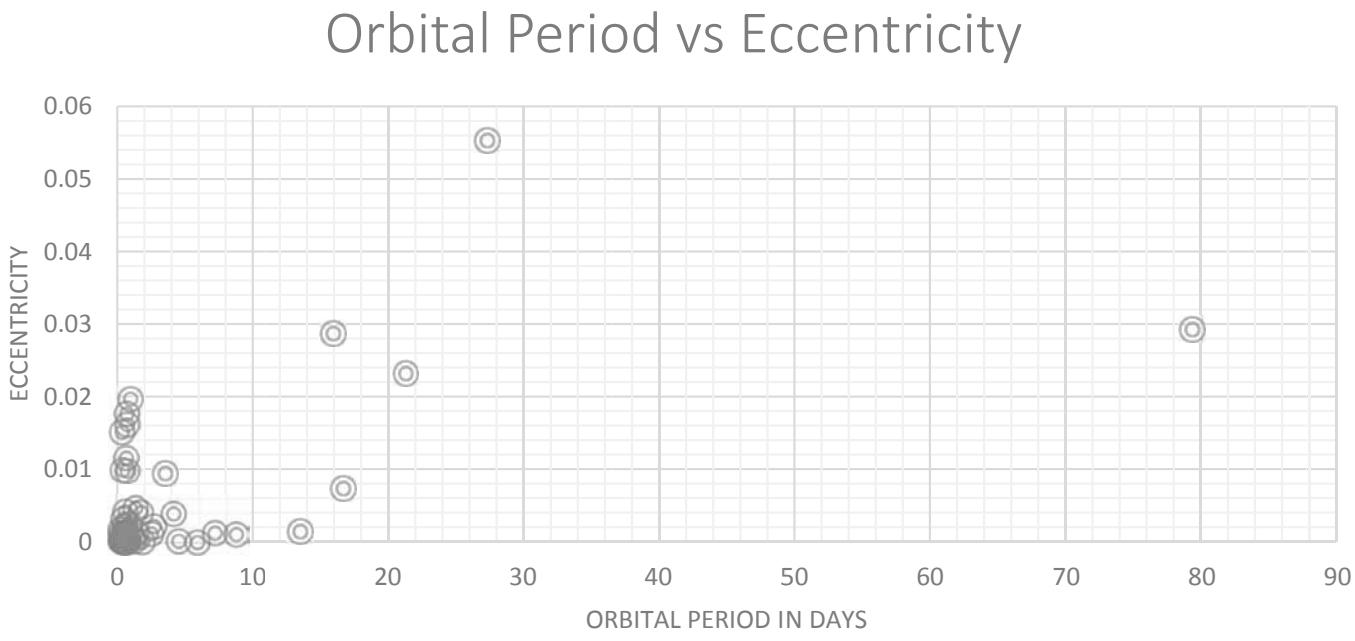

Figure 8. The plot of the eccentricity of 51 regular satellites shows that all satellites with an orbital period of 10 days or less have nearly circular orbits, with eccentricities of 0.02 or less. Satellites with an orbital period greater than 10 days can have more eccentric orbits.

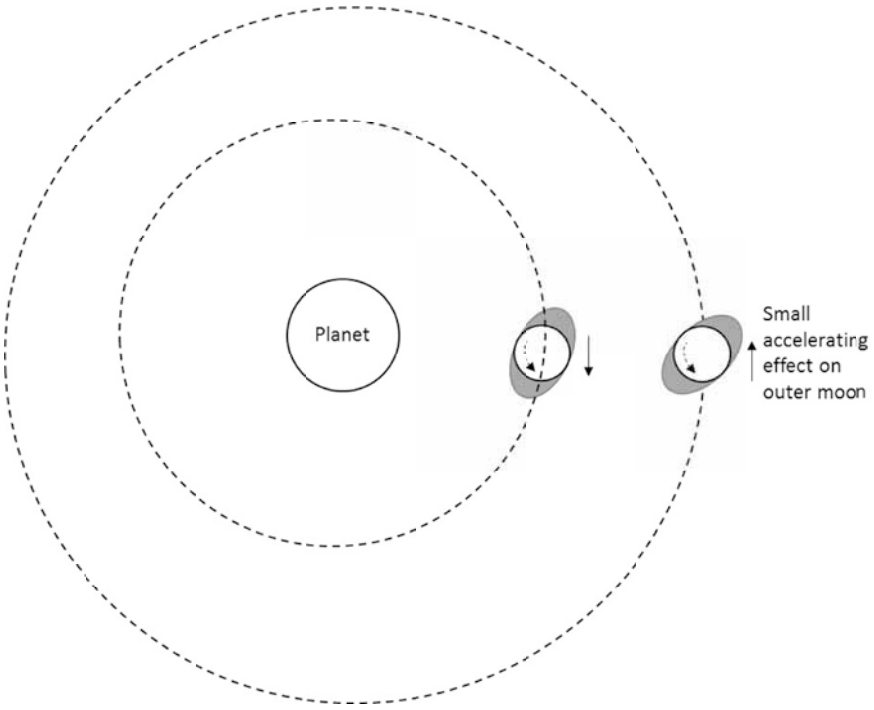

Figure 9. Tides on two Satellites. Both satellites raise tides on each other, and both rotate their tides forward. The inner satellite rotates more rapidly. When the satellites are in conjunction on the same side of the planet, the inner satellite's near side high tide will point ahead of the outer satellite, and the outer satellite's near side high tide will point behind the inner satellite. The gravitational pull of these tides will accelerate the outer satellite and decelerate the inner satellite.

the planet, the outer satellite's gravity pulls back on the tidal bulge of the inner satellite, decelerating the inner satellite and at the same time accelerating the outer satellite. The inner satellite pulls the tidal bulge of the outer satellite forward, with the same effect that the outer satellite is accelerated while the inner satellite decelerates. This effect is present regardless of whether the satellites are in a resonant orbit with each other, as some of the outer solar system satellites are. When the two satellites are on opposite sides of the planet, the tidal bulges get aligned in the opposite direction, so that the inner satellite is accelerated and the outer satellite is decelerated. However, when the satellites are on opposite sides of the planet, the distance between them is greater and the force involved is less, sometimes by more than an order of magnitude. Therefore, the tendency to decelerate the inner satellite and accelerate the outer satellite predominates.

This author is not aware of an accepted mathematical formula quantifying the tidal effects of a multiple satellite system, but it can be shown by analogy that this effect is weak. Io and Europa are the two closest large satellites in the solar system. At their nearest point, using equation (6), Io only accelerates Europa at a rate of 3 centimeters per century. Therefore, while all inner satellites accelerate all outer satellites and all outer satellites decelerate inner satellites, the conclusion should be clear that the tidal interaction between satellites is sufficiently weak that it has not played a significant role in the development of the solar system.

In a study based on analysis of historical eclipses in the Jupiter system, Lainey asserts that from 1893 to 2009, a period of 116 years, Io's semimajor axis has contracted by 55 km (kilometers, not meters), while Europa's increased by 125 km and Ganymede's increased by 365 km (Lainey, 2009). In other words, Io moved closer to Jupiter while Europa and Ganymede moved farther away. Since these satellites are moving away from each other, they should eventually escape their current 1:2:4 resonance. Whether this phenomenon is consistent or not with an old solar system could be the subject of further research. However, this analysis indicates that tidal forces between satellites are not the mechanism driving these changes.

Tidally Induced Heating

If a satellite were tidally locked and in a perfectly circular orbit, there would be no tidally induced heating on the satellite. When a satellite has an eccentric orbit, the tidal acceleration changes over the course of the orbit; it is greatest at periapsis, when the satellite is close to its planet, and least when the satellite is at apoapsis, farthest from the planet. The change in tidal force from periapsis to apoapsis creates a stretch/release process that can create friction and internal heat within the satellite. Also, a satellite in an elliptical orbit must rotate at a uniform rate, but it doesn't orbit around its planet at a uniform rate. Its tidal bulges move back and forth across the satellite a little and add to the tidally induced heating. Because tidally induced heating in this discussion deals with tidal forces created from the gravity of the larger body (the planet), this can be described as a strong effect. Tidally induced heating does not rely on a back reaction; it is a direct tidal effect rather than a secondary effect.

Tidally induced heating can be compared to squeezing (or stretching) a

Table 8. Tidal Force and "Stretch Factor" for Major Satellites.

Primary	Satellite	Mean Tidal Force	Eccentricity	Apoapsis/Periapsis Delta	Stretch Factor
Earth	Moon	2.44E-05	0.0554	8.19E-06	3.00E-07
Jupiter	Io	6.15E-03	0.0041	1.51E-04	8.55E-05
Jupiter	Europa	1.31E-03	0.0094	7.38E-05	2.07E-05
Jupiter	Ganymede	5.44E-04	0.0013	4.24E-06	5.93E-07
Jupiter	Callisto	9.15E-05	0.0074	4.06E-06	2.45E-07
Saturn	Titan	1.07E-04	0.0288	1.86E-05	1.16E-06
Neptune	Triton	4.14E-04	0.000016	3.98E-08	6.77E-09

Figure 10. Jupiter's satellite Io on November 17, 1997. Color mosaic photo from NASA's Galileo spacecraft, showing volcanic plumes. Photo courtesy of NASA/JPL-Caltech.

rubber ball. If the ball is squeezed with a constant level of force that never changes or flexes, there will be no heating due to friction. This is analogous to a satellite that is tidally locked and in a perfectly circular orbit. On the other hand, if the squeezing force increases and decreases periodically, the ball will flex and heat due to friction. This is analogous to a tidally locked satellite with an eccentric orbit, like almost all regular satellites in the solar system. The greater the difference in the maximum and minimum squeezing force, the greater the heating due to friction. Therefore, as the eccentricity of a satellite increases, the greater the differential tidal force and the greater the heating. Finally, if the ball is made to spin as it is being squeezed, the heating will increase further because the axis on which the ball is flexed will be constantly changing. Unlike the spinning ball, most regular satellites do not rotate now, but it is possible to postulate that if they did rotate in the past, their tidal heating would be greater than it is today.

Table 8 shows the tidal force acting on the seven largest satellites in the solar system and calculates a "stretch factor" based on each satellite's eccentricity, its rotational/orbital period, and the tidal force exerted by its planet. The stretch factor is a number without units, but it can give a comparative idea of the heating potential of the tidal forces on each body. This stretch factor is calculated by multiplying a satellite's orbital period by the difference in its tidal force at periapsis and apoapsis. The stretch factor is a measure of stress. Each satellite's ability to dissipate that stress will vary based on its composition and density.

The takeaway from Table 8, based on the far-right column, is that Jupiter's satellite Io has a far larger stretch factor due to tidal forces than any other large satellite in the solar system. Io's stretch factor is more than 250 times as great as what is experienced on the moon. Europa is in second place with four times less stretch factor than Io. Titan is a very distant third, followed in order by Ganymede, the moon, Callisto, and Triton. Correspondingly, Io is by far the most active tectonic body in the solar system, with constant volcanic activity, as shown in the Figure 10 photograph. Europa is tectonically active enough to have a smooth surface with few craters and possibly enough warmth for underground liquid oceans. Triton has shown geyser-like eruptions of nitrogen gas and dust. None of the other large satellites are thought to be very tectonically active.

Smaller icy satellites will dissipate heat more rapidly than the larger rocky satellites. Still, tidal stress on these satellites may cause tectonic activity. Since these are smaller satellites, their gravitational pull and corresponding escape velocity is weaker, and any tectonic activity, if it occurred, could cause matter from the satellites to be lost. Saturn's satellite Enceladus has a stretch factor of 5.26E-

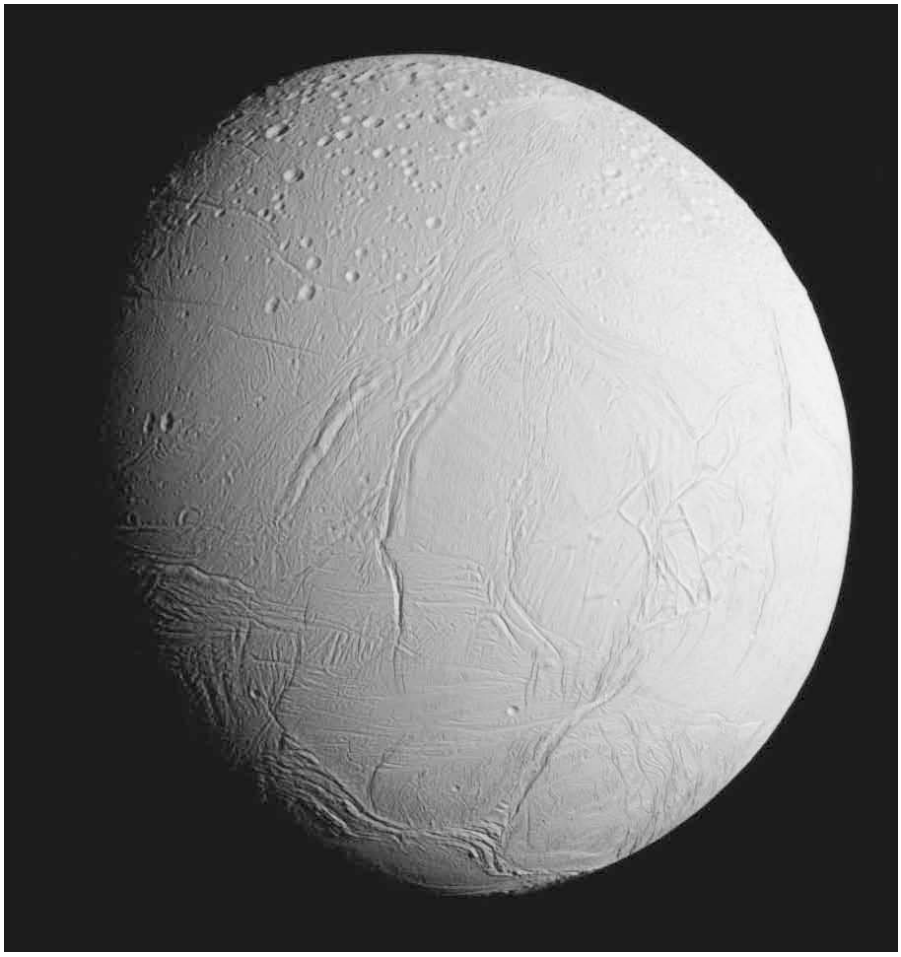

Figure 11. Saturn's Satellite Enceladus on October 28, 2015. Photo by the Cassini Spacecraft. Parts of Enceladus are cratered, but other parts have apparently been resurfaced by tectonic activity. Photo courtesy of NASA/JPL-Caltech.

06, more than all the satellites except Io and Europa. Enceladus has active geysers, and 200 Kg of material escapes the planet's gravity each day to form the E ring of Saturn (Czechowski, 2014). Unlike the more prominent inner rings, the E ring is outside Saturn's Roche limit. Figure 11 shows Enceladus, with evidence of portions of the satellite having been resurfaced by tectonic activity.

Most of the regular satellites in the solar system are tidally locked to their planet. However, in a theoretical scenario or early solar system scenario in which they were rotating with a 12-hour period, the cumulative stretch factor would increase, since in addition to being stretched once per orbit, they would also be stretched twice per 24-hour day. If their eccentricity were increased, that would also lead to increased heating, since the length of the stretch would increase. Table 9 shows how the stretch factor would change in two theoretical scenarios: (1) if instead of being tidally locked, all satellites were rotating with a 12-hour period, and (2) if instead of having nearly circular orbits, all satellites had the same eccentricity (0.0554) as Earth's moon.

The conclusion from Table 9, based on the two right-hand columns, is that

Table 9. Tidal Force and "Stretch Factor" of Theoretical Rotating Satellites.

Primary	Satellite	Mean Tidal Force on Satellite Surface	Real Stretch Factor	Stretch Factor if 12 Hour Rotation	Stretch Factor if 0.0549 Eccentricity
Earth	Moon	2.44E-05	3.00E-07	1.67E-05	3.00E-07
Jupiter	Io	6.15E-03	8.55E-05	3.88E-04	1.16E-03
Jupiter	Europa	1.31E-03	2.07E-05	1.68E-04	1.24E-04
Jupiter	Ganymede	5.44E-04	5.93E-07	9.07E-06	2.55E-05
Jupiter	Callisto	9.15E-05	2.45E-07	8.37E-06	1.84E-06
Saturn	Titan	1.07E-04	1.16E-06	3.83E-05	2.25E-06
Neptune	Triton	4.14E-04	6.77E-09	8.63E-08	2.37E-05

friction and heating in these theoretical satellites responds aggressively to greater rotation and eccentricity. The theoretical Europa's stretch factor becomes greater than the real Io, and most of the other theoretical satellites surpass the real Europa. This might then imply intense tectonic activity on all these satellites. The radical response of these theoretical satellites to such high levels of rotation or increased eccentricity can be a subject of further study and may constrain theories of the origin of the solar system. One example may be on Neptune's large satellite Triton, which has an orbit too circular to generate much tidal heating today. Triton shows evidence of tectonic activity, which may be due to its having a more elliptical orbit in the past. Since Triton is close to the planet Neptune, it could have circularized its orbit quickly, but not yet cooled sufficiently to dissipate all its tidally generated heat.

Conclusions

A young solar system creation model will need to assume that most regular satellites were created in an already tidally locked configuration, because the tidal locking effect takes too much time to start with rotating satellites. A young solar system will also need to assume that most regular satellites were created with orbits nearly as circular as they are today, because in most cases, not enough time has elapsed for tidal circularization to take place.

Tidal forces present several problems for an old solar system model. These include (1) The recession of the moon, which has been understood for years and is marginally increased when the moon's despinning is factored in; (2) the recession of at least four of Saturn's satellites and two of Uranus's satellites at rates similar to or greater than Earth's moon; (3) Earth should not be rotating faster than Mars and should probably already be tidally locked to the moon; and (4) tidal circularization does not provide an adequate reason for the nearly circular orbit of some bodies, like the planets in general or the outer satellites of Pluto.

The destructive capacity of tidal forces when a body enters its Roche limit could be factored into a young solar system analysis of comets. Since so many satellites are already within their Roche limit, future observations of changes in their orbits could indicate whether this fact has any bearing on the age of the solar system.

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The Challenges of Extrasolar Planets

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Abstract

Much has been learned about extrasolar planets in the past 20 years. An overview of the status of the research is presented, addressing exoplanet detection, planet formation and orbit migration, and issues that challenge current theories. Though the observational evidence of extrasolar planets is good in many cases, there are some difficulties in the analysis of the data and limitations of the methods. Extrasolar planetary systems often are very different from our own planetary system. Many known exoplanets are located closer to their stars than Mercury is to the sun. This has prompted development of theories for the migration of planet orbits. Migration theories have challenges in explaining why so many exoplanets have not spiraled into their star and have difficulty explaining exoplanets with orbits that are inclined compared to the equators of their stars. Recent reports from some researchers have expressed concerns that a surprising percentage of transit detections of exoplanets could be due to eclipsing binary stars or brown dwarf stars rather than exoplanets. Another challenge is the large radii of many so-called "hot Jupiters." Known mechanisms may not be adequate to explain the sizes of these planets. Though there is much interest in finding evidence of habitable extrasolar planets, there is still no clear evidence that any exist. The meaning of "habitable zone" is discussed in relation to extrasolar planet research. Extrasolar planets can be understood as being created on the fourth day of the creation week rather than forming from protoplanetary disks.

Introduction

For many years astronomers attempted unsuccessfully to detect evidence of planets orbiting other stars. Then in 1992, an extrasolar planet was found orbiting the pulsar PSR 1257+12 by the use of what is now known as the radial velocity (RV) technique. After some controversy over this discovery, soon there was confirmation of at least two planets orbiting PSR 1257+12 (Wolszczan, 1994), with reason to believe there were more. Since 1992, the technology and methods for detection of extrasolar planets (also known as exoplanets) have improved significantly.

In December 2015, the International Astronomical Union (http://nameexoworlds.iau.org) established

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official names for certain extrasolar planets, including the three planets orbiting PSR 1257+12. The discovery of planets orbiting a pulsar was a major surprise to astronomers. The question of the origin of such a system is still debated today.

There are now significant resources in terms of manpower and equipment that are dedicated to the search for exoplanets. In 2009, the Kepler spacecraft was placed into space in an Earth-trailing orbit. The Kepler spacecraft has dramatically increased the number of possible extrasolar planets known, as well as improved the data available on the objects it observes. Today the NASA exoplanet archive lists 3,373 confirmed exoplanets (NASA, 2016). "Confirmed" indicates that the detection has been confirmed by at least one research team, in addition to the discoverers. Most of these cases are likely to be extrasolar planets, but some are occasionally recategorized as observational errors, brown dwarfs, or other kinds of false positives.

The search for extrasolar planets is strongly motivated by evolutionary ideas and naturalistic assumptions regarding planet formation and the belief that life could evolve on other planets outside our solar system. It is thought that if life evolved on planet Earth, then it could evolve on other planets orbiting other stars, if the exoplanets are habitable. Thus, there is a great interest in finding Earth-like habitable planets orbiting other stars. (In extrasolar planet research, the term "Earth-like" primarily means similar in mass and size.) Statistical estimates based on various observations have been used to gauge the number of exoplanets there could be in in our galaxy. The number of exoplanets in our galaxy (the Milky Way) may be comparable to the number of stars in the galaxy, which implies approximately 100 billion (Clavin, 2012). This is a conservative estimate. The number of exoplanets in our galaxy easily could be double this due to the number of systems with multiple planets. However, this does not mean that life could exist on all these exoplanets.

Prior to the discovery of extrasolar planets 25 years ago, astronomers generally assumed that models of the formation of our own solar system could be used to explain planetary systems that might exist around other stars. But certain key differences were found between our own solar system and the extrasolar planetary systems. First, in many extrasolar systems the planets are so near their stars that the equilibrium temperatures would be too hot for gases to condense onto the planets' cores. Second, exoplanets are not always in "regular" or stable orbits. The orbits of the planets in our system have low eccentricities and low inclinations with respect to one another. Mercury has the most peculiar orbit, with an eccentricity of 0.21, and is tilted seven degrees with respect to the ecliptic, the plane of the earth's orbit. The low eccentricities and inclinations of planets in the solar system make their planet orbits quite stable. But in many exoplanet systems, the orbits are more elliptical than in our system. This makes gravitational interactions possible between planets (if there are multiple planets), and this could lead to the planets altering each other's orbits. Third, many exoplanets orbit so closely to their stars that their spin rates probably are tidally locked, just as our moon is in a tidal lock with Earth. The correct term for this is *synchronous rotation*, which means that the rotation period matches the orbital period. Consequently, this results in one side of an exoplanet always facing the star and the opposite side of an exoplanet always facing away from the star. Fourth, the stars that exoplanets orbit often are not so constant and stable in their energy output as the sun. These characteristics of extrasolar planetary systems have led to changes in planet origins theories. Some of the challenges to planetary science raised by exoplanets have been addressed in new theories, and some challenges are still largely unresolved.

Exoplanet Detection

The detection technique which is applicable to the largest variety of stars is the RV technique (Anderson, 2008; Knutson et al., 2014, Konacki, 2005). This is a spectrographic measurement of the Doppler motion of a star a planet may be orbiting. Due to Newton's third law of motion, the orbit of a planet around a star causes a periodic change in the velocity of the star. This is detected as a component of the star's velocity along Earth's line of sight. If more than one planet is present, there can be more than one superimposed periodic change in the star's radial velocity. As the star's redshift varies, observations over several orbits can sort out these multiple periodicities. It is necessary to rule out other types of variations in the star's light interfering with the measurement.

The RV technique is more effective when the exoplanet is nearer to the star, the exoplanet's mass is greater, or the star's mass is less. The exoplanet's orbit can be determined, assuming there is good data on the star and no complicating observational issues. Thus, the RV technique has a bias toward smaller stars and larger planets. In some systems where the star is more massive and the planet could be small, such a small planet may be more difficult to detect. Finally, if the star is far from Earth, the spectral signal may be weak, and this can limit the method. The RV technique is generally used for relatively nearby stars in our galaxy. Until 2014, there were more discoveries of exoplanets by the RV technique than by any other technique. The RV technique reveals an exoplanet's mass, but not its size (radius).

Since the Kepler telescope spacecraft was deployed in space in 2009, more exoplanets by far have been discovered using the transit photometry technique than any other technique

(Borucki et al., 2009; Steffen et al., 2010). Kepler is not the only instrument that does transit measurements, but it has been the most productive. The Kepler spacecraft has an array of cameras that simultaneously record the brightness of thousands of stars in a large patch of the sky. Sampling star brightness every twenty minutes, Kepler has discovered many variable stars. However, its intended purpose is to detect planets as they pass in front of their stars once each orbit. The transit technique works only if we lie very close to the orbital plane of an exoplanet. Therefore, most extrasolar planets would escape detection by this method. The fact that Kepler has found many exoplanets indicates how common extrasolar planets are.

The transit method reveals an exoplanet's size, but not its mass. However, if we can combine data from a transit measurement and the RV technique, we know both the mass and radius, and the exoplanet's density follows. There have been attempts to probe the atmospheres of exoplanets as they transit. As this technique improves, it may be possible to learn much more about exoplanets than was ever possible with the RV technique. In 2013, there was a failure of part of the pointing mechanism in the Kepler spacecraft. An innovative solution was found that allowed putting Kepler back into use but with certain limitations. The spacecraft must be aligned in a certain orientation in its orbit, and this limits the regions of the sky it can observe. The modification to the spacecraft to allow it to return to service has been called the K2 mission.

Another method, which is a variation on the transit technique, is transit timing variations (TTV). This method carefully determines whether transits start in a strictly periodic manner (Steffen et al., 2010; Xie, 2013; Barros et al., 2014). In some systems, this method can be used to verify other techniques. For example, if a system has more than one transiting planet (which is rare), it can cause variation in the transit timings. Or if an exoplanet orbits a binary star, there may be variations in the transit timing because the stars are moving. Note that in most cases even if a star has multiple planets, it may be that only one of the exoplanets has the proper orbit alignment and distance from the star to allow a transit measurement from Earth.

Direct imaging is becoming a more commonly used technique for detecting exoplanets. Direct imaging most often is attempted in the infrared part of the spectrum, because the difference in brightness between planets and their stars is least in the infrared. Furthermore, an occulting disk normally is employed to block the light of the star (Marois et al., 2008). If the light of the star can be sufficiently well characterized, it can be cancelled out, leaving the infrared glow of nearby planets in the image. This method allows direct observation of the motion of the exoplanets. The NASA exoplanet archive shows 42 cases of confirmed exoplanets detected with this method as of September 2, 2016.

Another method is gravitational microlensing. This uses an effect from general relativity in which a foreground star is used as a lens to image a much more distant star. The foreground star would be the star hosting the exoplanet. This technique can be used to detect exoplanets for stars much more distant, but it requires such precise alignment of the two stars that it is unlikely to ever happen again. The mass of the exoplanet can be roughly estimated, but determination of the orbit is very uncertain. There are some confirmed exoplanets using this technique.

Other methods used occasionally are eclipse timings of eclipsing binary stars, orbital-brightness modulation, pulsar timing, and pulsation timing from non-pulsar stars. In orbital-brightness modulation, light reflecting off the exoplanets causes variations in the star's light. There are a few pulsars with exoplanets. Pulsar pulse timings are a very good means of detecting planets orbiting them, because pulsars have extremely regular periods, so any motion of the pulsars due to orbiting planets shows up easily. Some variable stars have periods regular enough that this technique can be used to detect orbiting planets using the same method. Table 1 shows the number of confirmed extrasolar planets from various techniques as of September 2, 2016 (NASA, 2016).

Planet Formation and Migration

Planet formation theories start with a flattened disk of gas and dust around a newly formed star. This protoplanetary disk is supposed to be material that failed to amalgamate into the star. Presumably, the disk and star have the same composition, except that the disk may have a lower proportion of hydrogen and helium than the star has. Small particles of dust can collide and stick together. It is known from experiments that small particles (up to about 1 mm) can stick together due to static charge and other effects, but there has never been an adequate explanation of how solid rocky objects could grow to become sizable objects, such as 1 km in size. This is important, because computer simulations often start with model objects of 1 km diameter because simulations cannot effectively simulate objects growing to this size. The process of solid objects growing is often referred to as "accretion." But the dynamics of particles of different sizes and compositions colliding in a material medium is a complex mix of processes. If one assumes the planetesimal objects start at approximately 1 km diameter, then gravity may pull them together if they do not have too much velocity. But it is well known that even objects smaller than this 1 km size tend to break each other apart in collisions. The following extended quote from Halliday, 2003 (p. 516) explains the problems with small objects combining to make larger objects:

Table 1. Confirmed Exoplanets by Detection Method.

Detection Method	Number Confirmed
Transit Photometry	2664
Radial Velocity	593
Direct Imaging	42
Microlensing	39
Transit Timing	14
Eclipse Timing (Binary stars)	8
Orbital Brightness Modulation	6
Pulsar Timing	5
Pulsation Timing (non-Pulsars)	2
TOTAL	**3,373**

Table 1. Number of extrasolar planets listed in the NASA Exoplanet Archive (http://exoplanetarchive.ipac.caltech.edu/index.html) as of Sept. 2, 2016. Of the 2,664 transit detections above, 2,427 of these were with the Kepler telescope.

Laboratory experiments on sticking of dust have been reviewed by Blum (2000), who concluded that sticking microscopic grains together with static and Van der Waals forces to build millimeter-sized compact objects was entirely feasible. However, building larger objects (fist- to football pitch-sized) is vastly more problematic. Yet it is only when the objects are roughly kilometer-sized that gravity plays a major role. Benz (2000) has reviewed the dynamics of accretion of the larger of such intermediate-sized objects. The accretion of smaller objects is unresolved.

The process of accretion is something all planetary origin theories depend on, and yet there is no explanation for the physics of it, except for the formation of small dust particles millimeters to centimeters in size. Another group of authors examine the issue and give the following comments while discussing the early stages of the formation of our solar system (Montmerle et al., 2006, pp. 75–76):

> The growth from dust grains to kilometer-size planetesimals is still unexplained. … The simulations assume rocky objects, but it is still unclear how a puffy pile of dust becomes a solid rock.

In the early stages of the growth of planet cores, the key process is random collisions. This is usually referred to as "oligarchic growth." Once a planet core grows to a certain critical mass, estimated as about 10 Earth masses, then gravity is expected to be able to capture and add other material to the planet core in a rapid fashion. This is known as the "runaway" growth stage because it is believed both gases and solid material can rapidly accumulate on a planet's core in this period (Montmerle et al., 2006). A planet the size of Jupiter or Saturn must accumulate most of its mass in less than about 5 million years according to this scenario. If it does not accumulate its mass in this runaway stage, it never will, because the protoplanetary disk will dissipate. The original disk of gas and dust is essentially replaced with many planetesimals. The planetesimals have formed by the same accretion process assumed to form the larger planet cores. Planetesimals are solid objects made up of a variety of minerals, ice, and some organics believed to be very much like today's asteroids.

Smaller planets are thought to require longer times to form than larger planets. The size of planets is understood to be related to the density, thickness, and other properties of the disk. Rocky planets such as Earth or Mars are thought to form from random collisions of objects, often referred to as "planetary embryos." Planetary embryos are objects larger than planetesimals, possibly as large as Earth's moon, which could be made up of rock or ice. In several million years, a disk of dust would dissipate, leaving planetesimals and planet embryos.

The formation of planets is understood to be very dependent on the properties of the protoplanetary disk and other planets (or stars) present in the system. The properties of the star greatly affect the process as well. Near the star, the equilibrium temperature may be too high for gases to condense. Near some stars, even some metals may boil away

from planets. Planet orbit migration has come to be an accepted process in planetary science. Orbit migration was first considered as a means of allowing planets to form at a greater distance from the star than where they are observed today. This allowed more material to be available to accumulate on them in the early stages. For example, a planet could form at perhaps 4 or 6 A.U. from its star and then migrate inward. When the disk was depleted in some systems, planetary migration would stop. However, today there are believed to be multiple types of planet migration scenarios possible. Planet migration has been related to spiral density wave theory and planet-planet orbit interactions so that migration either can be inward toward the star or outward. Orbit migration has not really been observed except in the sense of cases where we can see that a planet has a decaying orbit, or perhaps a resonant relationship exists with another planet that could affect it in a predictable manner over a few years of observations. But orbit migration theory often involves planets moving very significant distances, perhaps as much as 5 or 10 A.U. in some cases. This kind of large-scale orbit change has not been observed.

Though the theories of planet orbit migration have received much attention in the scientific literature, such theories still have serious limitations and problems. The most serious problem may be that if a planet begins migrating inward, it tends to fall into the star. Scientists want to show how a planet migrating inward could migrate over a timescale that is longer than the time for the disk to dissipate. This would allow the planet to migrate inward until the disk dissipates. However, in scenarios planets migrate too rapidly and fall into the star before the disk dissipates (Hasegawa and Ida, 2013). A timescale on the order of 10^5 years is often estimated for the migrating planet to spiral into the star, but this depends on the system. This problem has been referred to as the "death spiral."

Migration theories are thus lacking in clarifying mechanisms that would stop the planet from spiraling into the star. There are two main types of migration that have received attention in the research, known as Type I and Type II (Plavchan and Bilinski, 2013; Hasegawa and Ida, 2013). In Type I migration, the disk is very massive compared to the mass of the planet, so that the planet's migration does not have a great effect on the disk. In Type II migration, the mass of the planet is greater, and the disk material is significantly affected by it. In Type II migration, a gap usually is opened in the disk due to absorption of gas and dust by the migrating planet. Both Type I and Type II migration scenarios involve the formation of density waves that can exist around the planet. The density wave can theoretically push the planet forward in the right conditions, making it spiral outward, or slow its motion, causing it to spiral inward. Spiraling inward is considered more common and is focused on more in the research to try to explain the many so-called "hot Jupiters" that exist close to their star.

As an example of a typical "hot Jupiter" type exoplanet, we can consider object Kepler-74. This exoplanet was referred to as KOI-200b, when it was first detected from a Kepler spacecraft transit measurement in 2012 (Hebrard et al., 2013). (The letters "KOI" refer to "Kepler Object of Interest.") The Kepler-74 designation was used after it was confirmed. It was confirmed by radial velocity measurements from two high-precision spectrographs, SOPHIE (in France) and HARPS-N (in Spain) (Hebrard et al., 2013). Kepler-74 orbits an F8V-class star with a mass estimated at 1.40 + 0.14, -0.11 solar masses and an estimated radius of 1.51 ± 0.14 solar radii. Kepler-74 is estimated to have a mass of 0.68 ± 0.09 times the mass of Jupiter (M_{Jup}) and a radius of 1.32 ± 0.14 compared to Jupiter (R_{Jup}). The star is estimated to have an effective temperature of 6,050 ± 110 Kelvin. The planet's orbital period is 7.34 days, and the eccentricity of its orbit is estimated to be 0.287 ± 0.062 (Hebrard et al., 2013). For comparison, Mercury in our solar system has an orbital period of 87.97 days and an eccentricity of 0.206. Kepler-74 is similar to many other cases of exoplanets.

An ongoing debate among exoplanet researchers continues over the question of how so many planets can migrate from some distance inward until they are very close to the star and then stop migrating. Several mechanisms for stopping migration have been considered (Plavchan and Bilinski, 2013; Nagasawa and Ida, 2011). The mechanism with the most promise is sometimes referred to as dynamical tides. The dynamical tide is the tidal force created by the star on the planet as a function of distance. If a planet has an orbit that is significantly eccentric (preferably more than Kepler-74), when it is at its point of closest approach to the star (periastron), tidal forces are greater than when it is at its farthest point (apastron). This tidal force tends to circularize planetary orbits as planets migrate closer toward their stars. Migration ought to cease once an orbit is sufficiently circular. Exoplanets close to their stars usually do not have significant eccentricities. Compared to other hot Jupiters, the eccentricity of Kepler-74 is somewhat high for a planet so near its star.

However, dynamical tides consider only half of the tidal physics. Some researchers may believe dynamical tides solve the migration problem in many cases. But even if an exoplanet's orbital eccentricity is close to zero, it can still spiral into the star. This is due to the tidal bulge raised by the planet on the star. When a planet is very close to the star, in many cases the planet may revolve more rapidly than the star rotates. The tidal bulge on the star induced by the planet may cause the planet to lose orbital energy and spiral inward. In addition, planets near their stars sometimes

lose significant mass from the star pulling gases off the planet. The rotation rate of the star and the size of the planet are significant factors in how the tidal forces affect the planet. The exoplanet can either spiral inward and be absorbed by the star or spiral outward to a more stable orbit in some cases. However, some researchers have argued that rather than looking for a mechanism for "saving planets" from spiraling into their star, perhaps they do not stop (Jackson et al., 2009). Perhaps tidal destruction is more common than halted migration. I find this line of argument to be more realistic, but more observations of these exoplanets over time and analysis of their dynamics are required to be more certain. Even if many of the hot Jupiters do spiral into their stars, it may require millions to billions of years. However, some exoplanets would spiral into their stars in only several hundred thousand years. These are only estimates arrived at from computer simulations.

Challenges to Current Theories

There are several ongoing challenges to current theories of extrasolar planetary systems listed below. All these issues are topics of great interest today in extrasolar planet research. They also give hints of possible advantages of a young-age creation view over an old-age naturalistic perspective. A creationist view can allow for supernatural formation of exoplanets in the creation week. Also in a creation approach, our own solar system becomes special in being a stable system that allows for life on Earth.

- Retrograde or high inclination exoplanet orbits
- False positives in transit measurements
- Gas planets whose radii are too large for their mass and distance from the star
- Problems with the habitability of exoplanets

High Inclinations of Exoplanet Orbits

In April 2010, the Royal Astronomical Society and the European Southern Observatory put out a press release announcing that six exoplanets were orbiting their stars in a retrograde direction, opposite the direction their stars spin (RAS/ESO, 2010). This was determined from transit observations. (These six cases have designations of WASP-2b, WASP-5b, WASP-8b, WASP-15b, WASP-17b, and WASP-33b.) One of the scientists involved, Andrew Cameron, professor from the University of St. Andrews in Scotland, made the statement, "The new results really challenge the conventional wisdom that planets should always orbit in the same direction as their star's spin" (RAS/ESO, 2010).

The evidence for high inclinations and some retrograde orbits among exoplanets comes from an observational technique known as the Rossiter-McLaughlin (RM) measurement (Bouchy et al., 2008; Fabrycky and Winn, 2009; Lund et al., 2014). The RM measurement examines an effect at the edges of the disk of the star as it is observed. On one side, the redshift will be greater because the surface of the star is moving away from the observer. On the other side of the star, the red shift will be less because the surface of the star moves toward the observer. This produces a predictable distortion in the redshift that allows estimating an angle that can be related to the spin axis of the star. An observer sees only a projection of the actual angle the star makes with the planet's orbit, not the actual angle. This projected angle is referred to as λ (lambda). The projected angle λ is what is measured in an RM determination. It is a projection of the actual angle between the star's spin axis and a line normal to the planet's orbit.

The actual angle between the star axis and the planet orbit is known as the stellar obliquity, and it is designated by ψ. The two angles λ and ψ are in two different planes (Fabrycky and Winn, 2009; Lund et al., 2014). Determination of ψ requires developing a detailed model of the star, such as from the changes due to stellar spots or from a technique known as asteroseismology. In asteroseismology, stellar oscillations are analyzed in terms of a sum of oscillation harmonics over time. An asteroseismology model can be compared to similar models of other stars and then applied to the star in question. The result is a model of the spectrum of the star as a function of its rotation. This allows determination of the star's obliquity.

RM measurements have been done only for a limited number of exoplanet systems. Data in Figure 1 come from a catalog of exoplanet transit data from Keele University, UK (Southworth, 2016). In this catalog, there were 166 exoplanets listed for RM measurements. Those which included both the λ and ψ angles were just 20 out of 166 as of September 2, 2016. Of these 20, four data points were of exoplanet HAT-P-07, and two were of HAT-P-11 (Table 2). The other 14 data points were each of different exoplanets (see Table 2). The chart shows the estimated actual obliquity angle on the vertical axis and the projected angle along the horizontal axis. The numeric values above each point show the angle ψ. In Figure 1, the points labeled 106 and 97 are the two HAT-P-11 measurements. This shows HAT-P-11 as being in a near polar orbit around the star, moving in a slightly retrograde manner. The data points labeled with 101 and 87 are two of the HAT-P-07 measurements. HAT-P-07b is also in a near polar orbit. The two HAT-P-07 data points on the graph had an error in ψ too small for the error bars to display. Some data points have a large amount of uncertainty, and the reported error varies significantly from one exoplanet to another. Four data points show a ψ value comparable to or less than the obliquity of our sun in our own solar system. The other 16 data points show a

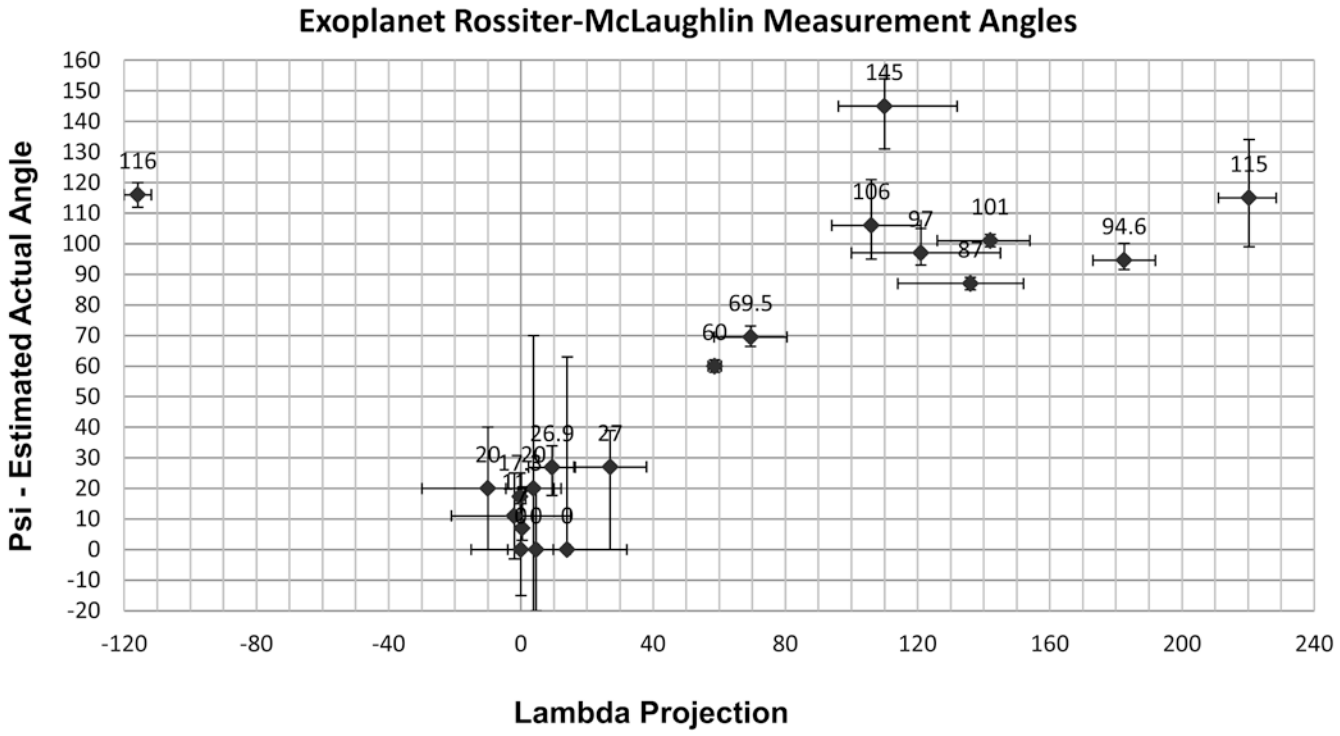

Figure 1. Chart showing exoplanet data from 20 RM measurements of 16 stars using data presented in Table 2. The estimated actual stellar obliquity angle ψ is plotted versus the projected angle λ. Numbers above the data points are the angle ψ in degrees.

higher ψ value than in our system. There appear to be two clusters of data points, one cluster at the lower angles and one at the higher angles. This trend has been noticed by exoplanet researchers, and it is often attributed to two different migration mechanisms. Though there is need for more RM measurements and perhaps more asteroseismology analysis for the exoplanet stars, the implied inclinations of the exoplanet orbits have been a challenge for planetary scientists. High inclinations of the exoplanet orbit compared to the star's axis are not explicable as due to the "traditional" process of planets forming from a protoplanetary disk.

The inclination of exoplanet orbits compared to the spin axes of their host stars is generating significant research today. In our own solar system, the orbits of all the planets are measured by the ecliptic plane, which is defined by Earth's orbit. Our sun's spin axis is tilted slightly over 7° compared to the ecliptic. This has been a challenge for models of the formation of our own solar system. In the traditional nebular hypothesis for the formation of our solar system, the spin energy of the star and the orbital motion of the planets must initially come from the spinning protoplanetary disk. This would make the orbits of the planets initially lined up with the equator of the star, and their orbital motion would be in the same sense as the spin of the star. This is accepted for extrasolar planetary systems as well, except that orbit migration is thought to explain how planets might exist today in different orbits than those that they initially formed in. Today, because planet orbit migration is considered to be common, it is thought that many systems may have had some planets spiral into their star and some other planets that may have been ejected out of their systems.

Type I and Type II migration described above are two forms of disk migration. In these models, the mass of the disk is primarily responsible for the migration of planets. Disk migration does not provide a mechanism to make planet orbits significantly tilted compared to the spin axis of the star.

Other theories for planet orbit migration have been proposed that are often referred to as planet-planet scattering. Planet-planet scattering is thought to explain highly inclined or retrograde exoplanet orbits. If a planet orbit changes in disk migration, it must happen early, in the first several million years of the

Table 2. Exoplanet data plotted in Figure 1.

Star Name	Effective Star Temperature (Kelvin)	Lambda (X) in degrees	Lambda Error	Psi (Y) in degrees	Psi Error
CoRoT-18	5440	-10	± 20	20	± 20
HAT-P-07	6310	182.5	± 9.4	94.6	+5.5, -3
HAT-P-07	6310	220.3	+8.2, -9.3	115	+19, -16
HAT-P-07	6310	142	+12, -16	101	± 2
HAT-P-07	6310	136	+16, -22	87	± 2
HAT-P-11	4780	106	+15, -12	106	+15, -11
HAT-P-11	4780	121	+24, -21	97	+8, -4
HAT-P-36	5620	14	± 18	0	+63, -0
HD_189733	5050	0.4	± 0.2	7	+12, -4
KELT-17	7474	-115.9	± 4.1	116	± 4
Kepler-13	7650	58.6	± 2	60	± 2
Kepler-17	5781	0	± 15	0	± 15
Kepler-25 c	6270	9.4	± 7.1	26.9	+7, -9.2
Kepler-63	5576	110	+22, -14	145	+9, -14
WASP-19	5460	4.6	± 5.2	0	± 20
WASP-32	6100	-2	+17, -19	11	± 14
WASP-52	5000	3.8	± 8.4	20	± 50
WASP-84	5280	-0.3	± 1.7	17.3	± 7.7
WASP-117	6040	69.5	± 11	69.5	+3.6, -3.1
XO-2	5332	27	± 11	27	+12, -27

Extrasolar planet data for cases plotted in Figure 1. Data obtained from http://www.astro.keele.ac.uk/jkt/tepcat/rossiter.html on Sept. 2, 2016.

formation of the system before the disk of gas and dust dissipates.

One form of migration is where planetesimals cause the migration of the planet. Migration via planetesimals happens after the protoplanetary disk is dissipated but while the planets are still accreting material from colliding planetesimals. This type of migration depends on the existence of a disk (or ring) of planetesimals that is massive enough to affect the planets' orbits. Migration by planetesimals also would not be expected to cause planet orbits to be tilted by large angles. Often planetary scientists seem to simply assume that the 7-degree angle in our own system somehow arose from random collisions in the planetesimal-accretion stage.

Another model for planet migration is where multiple planets form and their mutual gravity pulls them into resonance, so that their orbital periods are close to being whole number ratios of each other. If a system has multiple planets that can cause changes in each other's orbits, this process is considered something that can theoretically continue for long periods of time until something stops the process. If two planets come into a resonance, it is also dynamically possible that they could migrate together. Today a mixture of all these concepts has been applied to our own solar system in the Nice model (Tsiganis et al., 2005) and the Grand

Tack model (Walsh et al., 2011; Walsh et al., 2012). These concepts have been worked out from years of research on extrasolar planetary systems. Thus, scientists have attempted to develop theories that explain both other planetary systems and our own solar system.

One scenario for planet-planet scattering is known as Kozai cycles or Kozai oscillations (Fabrycky and Tremaine, 2007; Plavchan and Bilinski, 2013). The Kozai mechanism was originally developed as an explanation for how binary- and triple-star systems could come to have a near binary pair orbiting each other with a more distant companion star. If there is a star at a greater orbital distance than the binary pair, the distant companion can alter the inclination of the binary pair. The process could apply in some planetary systems where there are either multiple stars or multiple planets or both. It could apply if the system has a star (or a binary pair) that is orbited by a planet and there is another object, more distant and in an eccentric, highly inclined orbit. The distant object could theoretically be either a planet or a star. The distant object being in an inclined eccentric orbit can cause precession and oscillations of the inner planet orbit in this configuration. Over time the inner planet orbit in this scenario would become more eccentric for a time, but then as the planet orbit becomes closer to the inner star, the tidal forces from the inner star would round the orbit of the planet. So early in the Kozai cycles process the outer inclined object would affect the planet more, but later in the process the planet orbit has shrunk and then the tidal forces of the inner binary become more important. Computer simulations have been done of the mechanics of the Kozai cycles process.

The Kozai mechanism would not be applicable in a system with only one planet, but there could be some exoplanet systems where it could apply. There must be at least two objects orbiting a star not too far apart but in different planes if they are to influence each other gravitationally. In computer simulations, the Kozai process can produce planet orbits close to a star (or binary pair) that are highly inclined. Because the Kozai cycle mechanism is a slow process, it would require long periods of time, on the order of 1 or 2 billion years in simulations (Fabrycky and Tremaine, 2007). It is also possible that if a system has multiple planets in similar orbital planes that the planets can prevent the Kozai orbit oscillations. Multiple planets in similar orbital planes tend to stabilize the system, not increase orbital inclinations.

In extrasolar planet research, appeal often is made to the Kozai mechanism as a possibility, but it would not be applicable to many exoplanet systems. However, there are exoplanets in binary- and trinary-star systems. In some extrasolar planet systems, if there is evidence for a high inclination in a planet orbit, researchers sometimes merely assume that there was a distant companion object in an inclined orbit, whether there is observational evidence for such an object or not. If one is not observed, it can be argued that the distant object was ejected during the orbit oscillations of the Kozai process. A more distant exoplanet can be hard to detect, however, and exoplanets in distant orbits rarely undergo a transit. Showing that exoplanet orbits are undergoing a long-term change that is due to the Kozai mechanism would be difficult because we cannot observe the history of the exoplanetary system. The Kozai mechanism may require a distant companion planet that cannot be observed. Thus, the Kozai cycles scenario has limited applicability, even though it is a physically valid mechanism.

The Kozai cycles process generally ends with the exoplanet near its star (or binary pair) in a near circular but inclined orbit. But like other cases of hot Jupiter planets, it could still spiral into the star. The Kozai process attempts to explain how a distant object in a tilted orbit can cause another orbit to tilt. But it raises the unanswered question of how the distant object came to be in a tilted orbit. The Kozai mechanism gives some insight into how a system of multiple planets and multiple stars can change over time. In a creation view, it may be that planet-planet scattering and Kozai cycles do not have time to alter orbits greatly. In a naturalistic or uniformitarian approach to planetary systems, planet orbits must migrate by possibly several astronomical units over millions or billions of years. On the other hand, a creation alternative would be to view the exoplanets as being formed on the fourth day of the creation week at the time the star was formed. Then some limited migration could be possible over a young-age timescale.

Some exoplanet researchers have argued that high orbital inclinations could be related to various complicating observational effects and thus are not valid. One of the effects suggested is differential rotation in the star (Hirano et al., 2012). Stars may have latitude bands that rotate at different speeds, as does our own sun. Though differential rotation is probably common in stars, it is not clear how much it would interfere with transits or determinations of ψ. Another model was proposed suggesting that the outer layers of a star could "decouple" from the interior of the star, causing the star to have two rotation axes (Rogers et al., 2012). The star core and interior would have a different spin axis than the star's outer layers. It is not clear whether known exoplanets provide support for this model.

As more analysis is done of the data, these processes are likely to be either ruled out or better understood and better accounted for in models. The growing list of examples of exoplanets with possible high inclinations are not likely to all be explained away as observational issues. The highly inclined and retrograde exoplanet orbit issue seems to not go away, though better data and

analysis is needed to clarify it. Even if no exoplanets were found to have orbit inclinations more than 7°, that would only confirm that exoplanets have the same unexplained problem that has been found in our own system.

False Positives in Transit Measurements

In 2012 and 2013, scientists analyzing Kepler transit data realized that false positive detections with the Kepler spacecraft were much more common than had been expected (Santerne et al., 2012; Santerne et al., 2016). There are systems with eclipsing binary stars that can be almost indistinguishable from a planet transiting the star. One such case could be a brown dwarf that transits the star. Another case could be a blended binary, where a bright star is orbited by a binary pair that is less bright. Another case is known as a grazing binary system in which a dim star just barely overlaps the field of view of the other star. The grazing binary is thought to be the most common of these cases. The problem stems from apparently underestimating the number of eclipsing binary systems that could appear like planet transits.

The Kepler spacecraft was designed to be sensitive enough to detect the transit of an Earth-sized exoplanet, but this new issue of false positives will raise questions about reliably detecting such planets. There has been great interest in the scientific community in doing transit studies of exoplanets smaller than Jupiter or Saturn. Some have been found that are approximately double Earth's mass. These exoplanets are often referred to as "super-Earths." In some cases, the eclipsing binary possibility can be tested, given the proper analysis. But there are many transiting exoplanets that cannot be verified by the radial velocity technique. The radial velocity technique measures the change in the motion of the star due to the planet. For some transiting exoplanets, the velocity change in the star is too small to reliably detect with any instruments available today. This limits the ability of researchers to clearly show that the decrease in the star's light from Kepler is due to a planet and not an eclipsing star. In some cases, it will become a statistical argument rather than a physical argument to claim that it was an exoplanet that transited the star and not another star transiting the star. Virtually all Earth-sized or super-Earth exoplanets would be in this category. Thus, the problem of false positives from eclipsing binaries is a serious one, and in my opinion, it makes the detection of Earth-sized exoplanets very uncertain.

The false positives problem varies with the planet size and distance from its star. In 2012, Santerne et al. reported that for giant exoplanets with orbital periods of less than 25 days, the percent of likely false positives is 34.8 ± 6.5%. This was after studying a sample of 46 well-chosen transit cases. In 2015, Santerne et al. published updated results saying that as many as 54.6 ± 6.5 % of gas giant planets with orbital periods of 400 days or less could be false positives! This recent effort used a larger sample of Kepler Objects of Interest (KOI). Known false positives were first removed from the KOI list, and then the list was further parred down to those stars bright enough to be verified by the SOPHIE spectrograph (in France), leaving 2,481 KOI objects. Undoubtedly techniques will be refined to address this issue, but creationists should be cautious about accepting all claims of detection of exoplanets, especially for exoplanets orbiting very closely to their stars.

The Size of Gas Exoplanets

Another issue has become a significant ongoing mystery in extrasolar planet research: the sizes of many gas exoplanets near their stars. In recent years, scientists have noticed that many exoplanets near their stars have radii larger than expected in models (Baraffe et al., 2003; Anderson, 2010; Leconte, 2011; Southworth et al., 2014). There are several known effects that can cause a gaseous planet to expand near its star. But the magnitude of the radii for some exoplanets may defy all known mechanisms. The equilibrium temperature of the planet naturally increases as its distance from the star decreases. There is also a heating effect from tidal forces that can heat a planet near its star, known as *tidal dissipation*. Some would argue that tidal effects would heat these planets sufficiently to explain their large radii. But this has not really been shown clearly in tidal dissipation calculations. A recent paper (Martin, Spruit, and Tata, 2011) shows that this seems to require unrealistic values of the quality factor (Q), which is an important parameter in tidal dissipation calculations. The Q value has been estimated for Jupiter and various moons and planets in our own solar system. Estimates of Q frequently use a lower value for the star than for the exoplanet, and they use a value for the planet that is at least a magnitude higher than estimates for Jupiter in our own system. This is questionable because this tends to make the tidal force on the planet by the tidal bulge of the star less. I find it more likely the star would have a higher Q than the exoplanet.

The large radius of exoplanets also presents a time problem, because these planets are believed to form at some distance and migrate inward to near the star, then stop migration and remain stable for many years. As a planet migrates inward close to the star, it comes into synchronous rotation (tidal lock) with the star. At that point, one side of the planet cools very efficiently, because it is always facing away from the star. Though a gaseous planet in this configuration could have very high winds, and it might lose gases to the star, it would cool over long periods of time. But indications are that many of the "hot Jupiters" are hotter than expected from gas models and planet interior models.

However, this problem does not apply to all the exoplanets near their stars. For example, it would not apply to a planet with a high abundance of metals or a planet that is likely to have a large, dense core. An example case was discussed by Baraffe, et. al. in 2003. The following quote eloquently explains the nature of the issue (Baraffe et al., 2003, p. 712):

> In summary, we do not expect irradiation effects alone to explain the large observed radius of HD 209458b. In the same vein, tidal interactions will affect only the early stages of evolution of the planet but will probably be dissipated too rapidly to affect the long-term contraction of the object. Other sources of energy, representing about 100 times the intrinsic luminosity of the planet, seem to be required to explain the observed radius.

Exoplanet HD 209458b, mentioned above, has a mass of approximately 69% the mass of Jupiter, and yet its radius is roughly 30% more than Jupiter. A much more recent paper from Spiegel et al. (2014, p. 12623) made this statement summarizing the problem: "Despite the lack of a consensus mechanism, it is clear that objects must either be quite young or very highly irradiated to have significantly inflated radii." The expression "quite young" is not intended to mean several thousand years as in a young-age timescale. Planetary scientists have recently proposed a solution to the large radius problem by suggesting a collision event could have occurred in these systems (Martin, Spruit, and Tata, 2011). The collision proposed is referred to as a binary merger, and the authors suggest it could have taken place 100 million years ago or less. On the other hand, it would be a very plausible solution to propose that these "puffy" exoplanets have primordial heat that remains from their formation. But this does not fit planet formation models because the heat should have dissipated in billions of years. Thus, a catastrophic event has been proposed that generated a large ring that such an exoplanet could form from. Models of the gas dynamics of exoplanets very close to their stars require more research to clarify the problem. But this issue may be an indication of the young age of these exoplanets. Planetary scientists tend to look for an age in the millions of years to allow the dust ring to dissipate, the planet to form, and then allow the young planet to migrate inward. On the other hand, if these exoplanets were created supernaturally only several thousand years ago, they could still be hot and "inflated" from their formation. This is a tentative interpretation, but it does seem consistent with other evidence from our solar system (Spencer, 2003, 2015a).

The Habitability of Exoplanets

The driving motivation for much of the research on extrasolar planets is to find evidence of habitable planets like Earth. In recent years the technology applied to exoplanet research has improved, and this is driven by a desire to find smaller exoplanets, since it is believed this makes finding a habitable planet more likely. The concept of the "habitable zone" (HZ) has itself undergone refinements over the years. The HZ primarily is defined as the region around a star in which a planet having the proper atmosphere could have liquid water on its surface. How do planetary scientists set about the process of searching for habitable planets? Most of the time, they focus on low-mass dwarf stars. These stars usually have a lower mass than our sun, making it easier to detect even small planets by the RV method. Furthermore, the HZs of such stars are very close to the stars, yielding short orbital periods, making it more likely to observe transits. If both RV and transit measurements are made, we directly can determine the density of a planet. Scientists do not expect life to exist in gas giant planets, thus determining the density is important.

Transits may allow the determination of the major composition of planetary atmospheres (assuming the planets have atmospheres). The general requirements scientists look for on such a rocky exoplanet is that the temperature and pressure conditions on the surface allow for liquid water and that there be carbon dioxide (CO_2) in the atmosphere. Oxygen is not considered essential for life per se, but an atmosphere made up of mostly N_2, H_2O, and CO_2 is considered ideal for plant life to start. Thus, scientists generally look for a reducing atmosphere similar to what they believe Earth's early atmosphere was between about 3 billion and 2.3 billion years ago. Scientists believe it was because of photosynthetic bacteria that Earth's atmosphere switched from a reducing to an oxidizing nature approximately 2.3 billion years ago. Some scientists would consider an atmosphere more like the Earth's or Saturn's moon Titan to be more likely, where the major constituent is N_2 but there is a mixture of many organic gases, with some CO_2.

How common are rocky exoplanets? As of October 1, 2016, the NASA Exoplanet Archive listed 344 cases of confirmed exoplanets that showed both the semimajor axis and the density to be determined. Of these, 49 cases had densities 3.0 g/cm^3 or greater. Note that these 49 would be approximately 1.5% of the total of confirmed exoplanets in Table 1. (For comparison, Earth's moon has a density of 3.34 g/cm^3.) Of these 49, 5 show a density of 14 or more, with the highest as 28 g/cm^3. These high densities are probably suspect, so further research is needed on these cases. Error is not always reported in the density data and when it is, it is highly variable from one determination to another. Also, even if a very small error is reported, there are observational issues or data interpretation issues that could cause large errors, especially in light of the false positives problem discussed above.

How is the HZ defined? One of the best determinations of the HZ is published in Kopparapu et. al., 2013. For our solar system, the HZ is listed by Kopparapu as from 0.99 to 1.70 A.U. This distance range would start just inside Earth's orbit and range out to slightly past the orbit of Mars. There is thought to be some unknown error in this kind of estimate from the effects of clouds in climate models. This range of distances for the HZ is defined based mainly on the greenhouse effect as a function of distance from the star. It is thought that cloud cover tends to expand this range of distances. At the inner boundary of the HZ, water cannot be retained on the surface due to the high temperatures. At the outer boundary, the greenhouse effect is not significant enough to prevent water from freezing. Note that determining the range of distances from a star that would correspond to the HZ depends on making assumptions about the planet having an atmosphere. Often the assumption made for determining the HZ distance range is that the exoplanet has an atmosphere similar to Earth's in density. It has been estimated that if Earth's atmosphere disappeared, the surface would freeze. This shows how critical the nature of a planet's atmosphere is for habitability.

Even if a planet is in the HZ distance range, various effects can render it uninhabitable. First, most of the extrasolar planets studied with transit measurements probably are in tidal lock with their stars. If a planet is in tidal lock, the atmosphere could migrate to the cold side and then freeze out onto the surface. However, it is thought that if the atmosphere is dense enough, it would have a sufficient greenhouse effect and wind circulations to prevent this. A very challenging question would be, how could life find a safe place to live on a tidally locked planet? Such a planet would have extreme conditions on it that would not be very hospitable.

Second, many of the exoplanets are exposed to strong flares from their star, or bursts of ultraviolet or X-rays in some cases. This problem is likely to affect Proxima Centauri b for example, which was detected in August 2016 (Anglada-Escudé, 2016; Clery, 2016; Davenport et al., 2016). The star system Alpha Centuari has two stars referred to as A and B, and Proxima Centauri is thought to be a third star that is more distant but part of the same system. Proxima Centauri is a dwarf star, and it has an exoplanet that has been detected using the RV technique and has been confirmed. Proxima Centauri b orbits its star in 11.2 days, and the mass calculated for it is about 30% more than Earth. Orbital models of the Proxima Centauri system with its planet have been done, but since the RV measurement is the only data available, we cannot be sure of the mass since the RV technique gives only a minimum mass for the planet. Even if we knew its mass, we do not know its size, so the density of Proxima Centuari b is completely unknown. So, it could be more like Uranus or Neptune than Earth. Also, nothing is known of the composition of its atmosphere, or even if it has an atmosphere.

Stellar flares and radiation bursts are often far more intense for many other stars than what we experience from our sun. Our sun is exceptionally stable as a star. Another problem is that the planet could migrate inward to a position near the star early in that system's history, but then the star could boil off the water before life could get started (Spencer, 2015a).

For many of the exoplanets that are thought to be in the HZ for their stars, we know very little about them, because we do not know if they are rocky or gaseous. Large gaseous planets have their own reasons why life would be unlikely. They would have a high gravity and no solid surface, possibly limited water, little availability of light for bacteria, and they may possess ionizing radiation and magnetic phenomena that could destroy bacteria. The study of extrasolar planets shows how special our own planet and our own solar system are in being well suited to life and to our needs as humans.

Conclusions

Extrasolar planets are a very active topic of research in astronomy today. After many refinements of techniques and even special spacecraft being put into space for the observations, there remain many challenges to naturalistic theories on the origin of exoplanets. Experimental evidence for the existence of extrasolar planets is good in many cases, yet the limits of detection methods and the analysis of the data have many inherent challenges. Scientists want to find evidence of Earth-like extrasolar planets, but the primary discovery has been that extrasolar planetary systems are different from our own solar system. In many cases little is known about the exoplanets themselves. Though the Kepler spacecraft has done transit measurements for many exoplanets, there is a significant outstanding problem in that a large percentage of these detections could be false positives due to dwarf stars or eclipsing binary stars.

The existence of extrasolar planets is not in conflict with a biblical worldview, but naturalistic origins theories are. Extrasolar planets are often found to be very close to their star despite an apparent tendency for them to spiral in and be absorbed by the star. This may suggest these planets have not existed long enough to be absorbed by the star. Extrasolar planetary systems are not as safe or stable an environment as our own solar system is from our privileged place on Earth. Planet origins models have been adapted to incorporate the concept that planets can form in one orbit and then migrate to another, very different orbit. In these models, planets can form and fall into their star or be ejected into space. Exoplanets are sometimes found

in orbits that are inclined at angles very different from the equators of their stars. This has led to application of models in which multiple planets (or stars) that orbit in different planes can scatter or alter each other's orbits over time. This planet-planet scattering concept presumes a history for these systems that cannot be verified.

Planet origins models assume processes that often cannot be verified by observations. Some exoplanets have also been found with a radius that seems so large that it challenges existing theories. These large "puffy" exoplanets may be explained better as being young objects. Though some exoplanets are within the HZs of their respective stars, usually very little actually is known about these planets. Also, the possibility of liquid water on the surface of an exoplanet does not explain how life could evolve there from nonliving matter. The planet's atmosphere and stellar flares are critical factors that rule out life on many exoplanets. Extrasolar planets are best understood as examples of the variety created by God to demonstrate design in our own solar system. Extrasolar planets could have been created in the creation week on the fourth day only thousands of years ago. Exoplanets could have been created in various orbital configurations in the beginning, rather than forming from a spinning disk of dust and gas.

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Have Creationists Overlooked an Abundance of Biblical Cosmological Data?

Jake Hebert*

Abstract

Recently Faulkner has proposed that the "waters above" of Genesis 1:6–8 form a boundary beyond the farthest galaxies and that Genesis 1:1 is an introductory encapsulation of the events of Creation Week, rather than the first event in the sequence of God's creative activities. I examine arguments for and against these views and attempt to derive additional cosmological implications from the former. I also examine several scriptural passages that may be cosmologically relevant but which seem to have gone overlooked by many commentators. For instance, the Bible may give us clues regarding the location of God's abode, the large-scale spatial geometry of space, and hints as to whether our universe is expanding.

Introduction

The correct identification of both the "expanse" (Hebrew *raqîa'*) of Genesis 1:6–8 and the "waters above" the expanse are critically important issues in constructing a biblically based cosmology. Earlier creation scholars equated the expanse with Earth's atmosphere and the "waters above" with a pre-Flood vapor canopy (Whitcomb and Morris, 1961; Dillow, 1982). However, Humphreys (1994a, 1994b) has made a strong exegetical argument that the expanse is actually intergalactic space and that the "waters above" are a shell of water beyond the farthest galaxies. In addition, attempts by Rush and Vardiman (1990) and Vardiman and Bousselot (1998) to model the effects of a vapor canopy have been disappointing, as they suggest intolerably hot temperatures for Earth's surface.

In Humphreys' model, the space of our physical universe extends beyond this spherical shell of water (Figure 1). Humphreys (1994b, p. 65) referred to this space as the "second heavens" and argued that it is created and of finite extent. Humphreys has since modified his model somewhat, although to the best of my knowledge he has not published the newer version in the technical literature. It is not completely clear to me, based on the online description (personal correspondence cited in Hartnett, 2014) of the newer model, whether his revised model agrees with the proposal discussed below.

Recently, Faulkner (2016) has echoed Humphreys' suggestion. I find this proposal worth considering for several reasons.

First, the most natural understanding of Genesis 1:6–8 is that God divided the waters so that the waters above the expanse formed a spherically symmetric shell centered on Earth. If this is the case, and if the waters are a kind of boundary for our universe (as I will suggest here shortly), then it automatically follows that our physical universe

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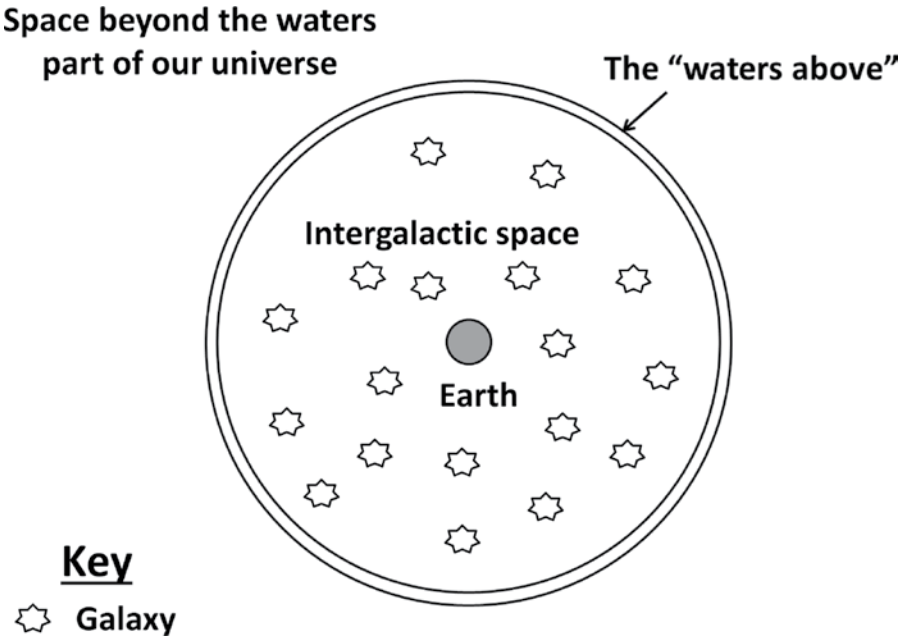

Figure 1. Humphreys (1994b) suggested that our physical universe extended beyond the "waters above" and that this space might or might not contain matter.

is finite in extent, which agrees (as noted by Humphreys, 1994b, p. 65) with I Kings 8:27:

> But will God indeed dwell on the earth? behold, the heaven and heaven of heavens cannot contain thee; how much less this house that I have builded? (KJV)

Humphreys (1994b, p.65) seems to have assumed that the "heaven of heavens" (also rendered as "highest heavens" in some translations) refers to interstellar space, but it could be that the "heaven of heavens" rather refers to the dwelling place of God (Heaven with a capital "H," if you will). If that is the case, then Heaven is of finite extent. If the "heaven of heavens" (Heaven) is of finite extent, then the smaller sidereal heavens would be, as well.

Second, if the shell is centered on the earth, as one would tend to assume, it would imply that the earth does indeed occupy a privileged place in the cosmos.

Third, as noted by Faulkner (2016), the waters might be the source of the cosmic microwave background radiation. In that case, it might be possible to make testable cosmological predictions.

Fourth, such a view would explain why these waters apparently still exist, even after the Flood (Psalm 148:4).

What is on the Other Side of the Waters?

However, this immediately raises another question. What is on the other side of the watery shell? In Humphreys' original model, the space of our physical universe extended *beyond* this spherical shell of water (Figure 1). However, this begs more questions. What would be the point of God establishing a space beyond these waters, which would seem to be inaccessible to us but which would (presumably) have not been part of the abode of God? Humphreys suggested that this space beyond the waters (which, again, would still be part of our universe) could contain matter (Humphreys 1994b, p. 65), but this seems somewhat problematic. Given that God wants us to know that He is the Creator of *all* things (Colossians 1:16, Revelation 4:11), why would He not explicitly tell us about His creation of this supposed matter beyond the waters? And if this space beyond the waters is devoid of matter, then what is the point for its existence?

Faulkner (2016) was careful not to speculate about what lay directly on the other side of the "waters above," and he has stated in a personal communication (Faulkner, 2016, personal communication) that the abode of God does not have to be directly on the other side of the waters. However, what if this truly is the case? What if the abode of God is *directly* on the other side of the "waters above" (Figure 2)? Here I present several arguments in favor of this view.

First, the idea of waters as a boundary between our universe and Heaven itself seems conceptually simple. In fact, in a private conversation with other creationists on this topic, someone suggested that the "sea of glass like unto crystal" described in Revelation 4:6 and Revelation 15:2 may refer to these waters but as described from *above*, from the point of view of Heaven's inhabitants. The simplicity of such a view is very appealing, and there is a certain "symmetry" to it. We are first introduced to these waters at the beginning of the Bible in Genesis 1:6–8, but from our earthly perspective *under* the waters. We again see the waters at the end of the Bible, in Revelation 4:6, but this time from a heavenly perspective, *above* the waters. Other writers have also suggested a possible connection between "the waters above" and the crystalline expanse (Bassett 2011), although they may disagree on the details of that connection.

Second, such a view might also help to explain a passage that most of us probably have been hesitant to take literally:

> Bless the Lord, O my soul. O Lord my God, thou art very great; thou art clothed with honour and majesty. Who coverest thyself with light as

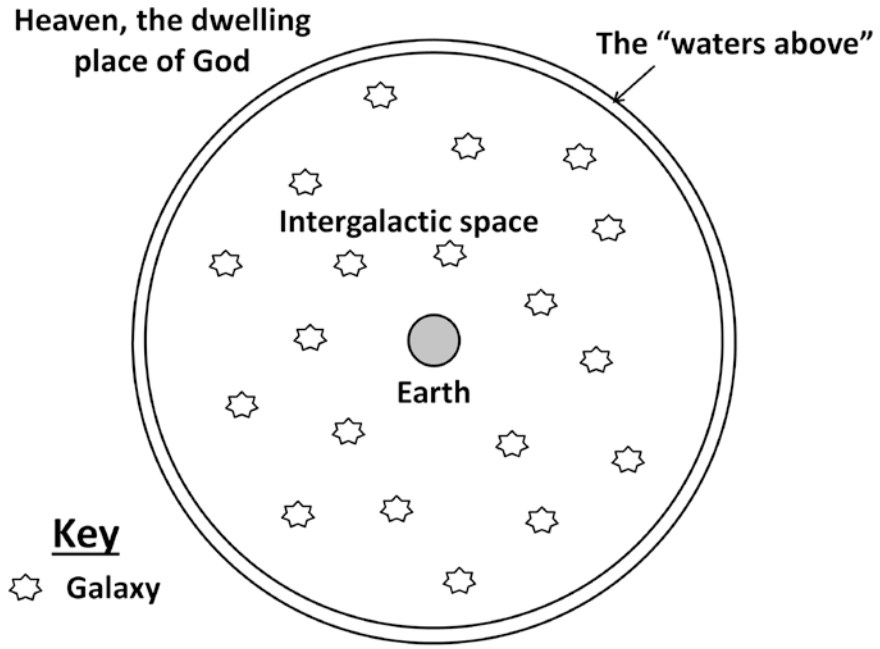

Figure 2. Do the "waters above" form a boundary between our universe and Heaven, the abode of God?

> with a garment: who stretchest out the heavens like a curtain: W*ho layeth the beams of his chambers in the waters*: who maketh the clouds his chariot: who walketh upon the wings of the wind: Who maketh his angels spirits; his ministers a flaming fire. (Psalm 104:1–4, emphasis mine)

Although this language is indeed poetic, could it be revealing a literal truth? The tendency is to assume that the "waters" in Psalm 104:3 are the waters of the clouds. Parallelism is a major, if not defining, characteristic of Hebrew poetry and at first glance it is easy to assume that the statement that God "layeth the beams of his chambers in the waters" (v. 3) is parallel to the statement that He "maketh the clouds his chariot." Of course, the skeptic would dismiss this as a naïve, prescientific view that God's "house" is somewhere in the clouds.

But is the statement that God "layeth the beams of his chambers in the waters" parallel with the statement that God "maketh the clouds his chariot," or is it actually parallel with the preceeding statement that God "stretchest out the heavens like a curtain"? Note that this alternate grouping of parallel thoughts seems to make good overall sense:

> Thou art clothed with honour and majesty / Who coverest thyself with light as with a garment
>
> Who stretchest out the heavens like a curtain / Who layeth the beams of His chambers in the waters
>
> Who maketh the clouds his chariot / Who walketh upon the wings of the wind
>
> Who maketh his angels spirits / His ministers a flaming fire

In that case, the waters would seem to refer to the waters above the *raqîa*' rather than to clouds. Thus, this statement, though expressed in poetic form, would be literally true, if God *really has* laid the beams of his heavenly chambers in the waters above the *raqîa*'.

Of course, one might object to such a literal understanding of the "chambers in the waters," since one could use the same reasoning to argue that God *literally* walks or travels through the atmosphere, an "obviously" nonsensical conclusion. But is it really nonsense? Does not Scripture repeatedly teach this? This idea is expressed poetically in many other passages (2 Samuel 22:11–12; Job 22:14; Psalm 18:11; 68:33; 97:2; Nahum 1:3). We can certainly safely say that such a statement *at least* applies to the Lord Jesus after his resurrection (Daniel 7:13; Matthew 24:30; 26:64; Mark 13:26; 14:62; Acts 1:9; 1 Thessalonians 4:17; Revelation 1:7).

If this is the case, then this would imply that, fundamentally, there are just two "heavens," the 3-D space of our universe, and the abode of God. I tend to lean toward the idea that God created both these heavens at Genesis 1:1. In fact, the 3-D space of our universe may be of the same substance as the space of Heaven itself, an extremely interesting conclusion in its own right.

A Watery Divide Between Our Universe and Heaven? Possible Biblical Objections

Of course, the point made above immediately raises a potential objection: If there are only *two* heavens (the space of our physical universe and the abode of God), then why does Paul refer to the abode of God as the *third* heaven (2 Corinthians 12:2–4)?

One possibility is that one could reasonably divide the physical space of our universe into two realms, the atmospheric heavens and the sidereal heavens, but one could also reasonably choose to "lump" them together. In fact, Faulkner (2016) has made the point that the distinction between the atmospheric and sidereal heavens is perhaps not as clear-cut as we tend to think.

J. Johnson (personal communication) has pointed out that Scripture

already does this with the concepts of *soul* and *spirit*. Some passages of Scripture seem to suggest that man has two fundamental parts, body and spirit (Ecclesiastes 3:19–21; 12:7; Zechariah 12:1; Matthew 26:41; Mark 14:38; Luke 8:55; 23:46; John 3:6; 6:63; Acts 7:59), but others suggest that man has three components, body, soul, and spirit (1 Thessalonians 5:23; Hebrews 4:12). Indeed, Scripture itself suggests that it is difficult to distinguish between soul and spirit (Hebrews 4:12). Hence, the fact that Paul seems to refer to the abode of God as the *third* (rather than the second) heaven may not be a fatal objection to this view. It may be that one can reasonably claim that there are three heavens, or just two, depending on whether one chooses to make a distinction between the atmospheric and sidereal heavens.

A second objection is that the "sea of glass like unto crystal" described in Revelation 4:6 and the "sea of glass" described in Revelation 15:2 seem to be solid or crystalline, rather than liquid, yet the waters that would become the "waters above" were originally in liquid form, and presumably still are (Psalm 148:4). I don't have a "solid" answer to this (pun intended!), but it is possible that the waters are now in a frozen, rather than a liquid, state. Or, as one reviewer suggested, perhaps the "sea of glass" is only a small portion of the heavenly shell of water so that most of the water is in a liquid state, but not all of it.

Third, this view implies, as already noted, that God created both the sidereal heavens and the Heaven of his abode on Day 1 of Creation Week. Yet, there are verses in Hebrews that seem to suggest that Heaven, though created by God, is *not* part of our physical universe. Hebrews 9:11 says,

> But Christ being come an high priest of good things to come, by a greater and more perfect tabernacle, not made with hands, that is to say, not of this building.

Comparison of the above verse with Hebrews 9:24 makes it clear that this "greater and more perfect tabernacle" is the abode of God:

> For Christ is not entered into the holy places made with hands, which are the figures of the true; but into heaven itself, now to appear in the presence of God for us.

Of course, one might worry that if Heaven is not part of our (created) universe, could it have been uncreated? This is a very disturbing possibility, as it would seem to suggest that something exists that God did not create, which seems to contradict Scripture (Colossians 1:16), especially because what we call "space" may be a substance of some kind. Fortunately, however, this disturbing possibility is ruled out by Hebrews 8:1–2, which makes it clear that Heaven itself, the third heaven, *was* created by God:

> Now of the things which we have spoken this is the sum: We have such an high priest, who is set on the right hand of the throne of the Majesty in the heavens; A minister of the sanctuary, and of the true tabernacle, *which the Lord pitched, and not man*. (emphasis mine)

But that still leaves the question, *Is the abode of God part of our physical universe*? If the abode of God is part of the heavens created on Day 1, then the answer would seem to be *yes*. Yet Hebrews 9:11 seems to be saying *no*, and it is worth noting that the word used in Hebrews 9:11 is routinely rendered as *creation* in many other verses:

> But from the beginning of the creation [*ktisis*] God made them male and female. (Mark 10:6)
>
> For in those days shall be affliction, such as was not from the beginning of the creation [*ktisis*] which God created unto this time, neither shall be. (Mark 13:19)
>
> For the invisible things of him from the creation [*ktisis*] of the world are clearly seen, being understood by the things that are made, even his eternal power and Godhead; so that they are without excuse. (Romans 1:20)
>
> For the earnest expectation of the creature [*ktisis*] waiteth for the manifestation of the sons of God. For the creature [*ktisis*] was made subject to vanity, not willingly, but by reason of him who hath subjected the same in hope, Because the creature [*ktisis*] itself also shall be delivered from the bondage of corruption into the glorious liberty of the children of God. (Romans 8:19–21)

I don't have a final answer to this difficulty, except to note that perhaps the abode of God ("the third heaven"), though also presumably created on Day 1, may perhaps still be considered "separate" from the sidereal heavens, due to the watery boundary between them. Indeed, it is worth noting that the word *ktisis* can be rendered "building," which seems to parallel the thought expressed by King Solomon in 1 Kings 8:27. In that case, it might not be incorrect to think of the third heaven as a separate structure or building of sorts, even though it is of the same substance as the substance of our 3-D space and was created on Day 1.

Is Genesis 1:1 an Introductory Encapsulation?

Faulkner also argues that Genesis 1:1 is what is known as an introductory encapsulation, which means that it could simply be an overview of the events of Creation Week rather than the very first event in that sequence of events. In that case the *raqîa'* did not exist until Day 2 (Faulkner 2016). I have some concerns with this view (stated below), although arguments have been made for it by conservative scholars (Faulkner 2016). However, I do not think that it is necessary to argue that Genesis 1:1 is an introductory encapsulation in order to conclude, as Faulkner does, that "the

waters above" lie beyound the farthest galaxies.

One concern has been pointed out by Humphreys (1994b, p. 65). If Genesis 1:1 is merely an overview of the sequence of events of Creation Week, rather than the very first event in that sequence, then God nowhere tells us explicitly in the Genesis account that He Himself created the matter that would eventually become the earth and other celestial bodies. This again raises the disturbing possibility that something in the cosmos is uncreated, which was a common theme in most, if not all, pagan cosmogonies (Morris, 1989).

Second, if Faulkner is correct that the physical space of our universe (the *raqîa'*) was not made until Day 2 of the Creation Week (Genesis 1:6–8), then how could the watery mass described in Genesis 1:1–2 even *exist* on Day 1? A mass needs *some* space in which to exist, and there are multiple clues within Genesis 1:2 that suggest a space of some kind was already in existence:

> And the earth was without form, and void; and darkness was upon the face of the deep. And the Spirit of God moved upon the face of the waters.

The phrases "face of the deep" and "face of the waters" clearly imply spatial dimensions, which require a space of some kind. The same may be true for the phrase "without form and void." But if the expanse did not come into existence until Day 2, then what is the identity of the space that contained the watery mass of Genesis 1:2?

A third objection to the idea that the expanse came into existence on Day 2 is that Scripture says that God *made* the *raqîa'* on Day 2 rather than created it. If the expanse is equivalent to the entirety of the physical space of our universe and the expanse did not exist until Day 2, then it would seem more appropriate to use the Hebrew word for *create* (*bara'*), rather than *make* (*`asah*) to describe God's actions on Day 2 (Genesis 1:6–8). But the fact that God *made* the expanse seems to suggest that the space was already in existence on Day 1 and that God merely altered the space somehow on Day 2 to make (not create) the expanse. The most obvious possibility would be that on Day 2 God stretched the space created on Day 1 to make the *raqîa'*. However, as pointed out by Hartnett (2011), the verses commonly cited as evidence for such a "stretching" of space may not actually be claiming this.

Hence, I tend to think that Genesis 1:1 *must* be the first step in God's creative activities, although it could also simultaneously be an introductory encapsulation. However, I don't think that it can be *merely* an introductory encapsulation.

Do We Live in a Spatially "Flat" Universe?

Does the Bible give us a clue regarding the geometry of our universe? Ordinary Euclidean geometry assumes that parallel lines in our universe never converge or diverge. Likewise, in Euclidean geometry, the sum of the measures of the angles of a triangle must always be 180°. Such a case would correspond to a "flat" universe. But one can also have geometries in which this is not the case. For instance, Euclidean geometry does not hold on the surface of a sphere characterized by a positive spatial curvature. On a sphere, the sum of the measures of the angles of a triangle is greater than 180°.

Big bang cosmologists claim that our geometry is "flat," but this claim usually is based on big bang assumptions that creationists do not accept (de Bernardis et al., 2000).

However, Genesis 1 may be suggestive of a geometrically "flat" universe. Imagine that on Day 2 of Creation Week, the watery (and presumably spherically shaped) mass that will become the earth is bounded by a large imaginary box. Suppose we could observe God on Day 2 moving the "waters above" out billions of light-years to their current location. This could be done either by moving the waters themselves or by stretching or expanding the space between the waters. In my view, the latter is more likely, since God *made* the expanse on Day 2, which suggests that God actually *did something to the space* between the waters, rather than merely move the waters apart from each other *within the space*. Although the text does not explicitly say so, it seems reasonable to assume that the "waters above" remained in the form of a shell concentric with the earth as God moved "the waters above" to their new position. But in this case, the shell itself, at its new location, is bounded by another, even larger imaginary box. But here is the important point: for the shell to remain concentric with the surface of the earth, the six faces of the smaller box must each be parallel to one of the corresponding six faces of the larger box. And this implies that a 2-D "slice" through the 3-D space (Figure 3) will reveal lines that are tangent to the earth's surface at four locations, as well as lines that are tangent to the shell at four corresponding locations. And because the shell is presumably still concentric with the earth, the corresponding lines will be parallel. Since the faces of the largest box are literally at the very edge of the universe, this would imply that parallel lines in our universe never converge or diverge, which is a defining characteristic of a "flat" spatial geometry.

It might be possible, however, that Heaven itself, being possibly finite (1 Kings 8:27), does have a positive spatial curvature but we simply don't notice it, because our universe is too small (!) to notice this curvature if we stay inside the watery boundary.

Is the "Space" of Heaven the Same Substance as Interstellar Space?

If part of the heavens in Genesis 1:1 really is the "third heaven," the dwelling place of God, then this may have many

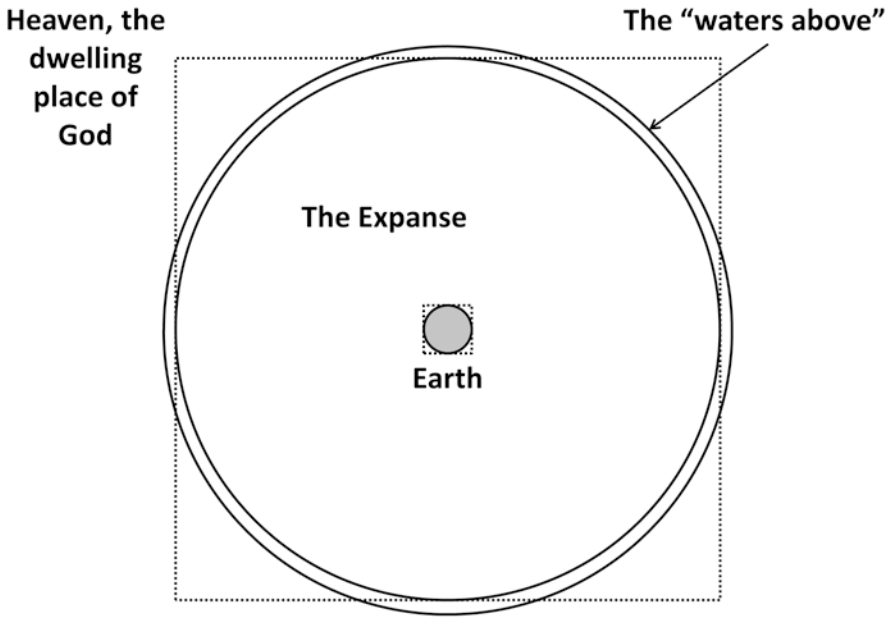

Figure 3. If the "waters above" were still concentric with the surface of the Earth after God moved them to their new location (Genesis 1:6–8), then both the Earth itself and the "waters above" could be contained within large imaginary boxes. The corresponding faces of the two boxes would be parallel, suggesting a "flat" spatial geometry.

significant physical implications. First, it might suggest that the space of God's abode is not that different from the physical space of our cosmos, although the space of our physical universe may have been stretched to form the *raqîa*'. As noted earlier, the two heavens may have been "blurred" together until God divided them with the "waters above." If the "stuff" of interstellar space is the same as the "stuff" of the space in Heaven, this has even more intriguing implications. Is the space-time of our physical universe the same as the space-time of Heaven itself? Does relativity theory apply in Heaven, as well as our universe?

However, one reviewer raised an interesting question: If I am suggesting that our universe is just a subset of the larger heavenly space (the space above the earth's surface), then what about the space *below* the earth's surface? What about the space inside the earth's interior? Specifically, what about hell? There is overwhelming scriptural evidence that the abode of the unsaved dead (hades or hell) is within the earth's interior, presumably at or near the center of the earth (Numbers 16:29–33; Psalm 86:13; 139:8; Proverbs 5:5; 7:27; 9:18; 15:24; Isaiah 14:9, 15; Ezekiel 31:16–17; 32:27; Amos 9:2; Matthew 11:23; Luke 10:15; and possibly 1 Samuel 28:11–15). Yet the earth's inner core is thought to be solid. How is this possible?

This may not be a serious objection, since spirits seem to be unhindered by physical objects, anyway. However, there is another factor worth considering. If God indeed made the *raqîa*' by stretching a preexisting space that He created on Day 1 of Creation Week, then it may be that this stretching was applied only to the portion of space *above* the earth's surface. Presumably the space *below* the earth's surface would *not* have been stretched (note that Genesis 1:6 seems to imply that the *raqîa*' does *not* extend below sea level). In that case, the space in the earth's interior may be similar to Heaven in that both are unstretched. This common feature might be a clue to explaining how spiritual beings can live in these spaces, even when the space coincides with a solid or liquid object (like the inner or outer core).

An Expanding Universe… or Not?

If the "waters above" form a boundary to our universe, does this rule out an expanding universe? If one assumes that the shell of waters serves as an interface between our universe and Heaven itself, then the waters must simultaneously be part of both our universe and the abode of God. If they are part of our universe, it would seem that the mass of the waters cannot increase or decrease, due to the fact that God (with the exception of some miracles) is no longer creating new mass/energy (Genesis 2:1–2; Hebrews 1:3). But if the waters are in a liquid or solid state, this implies that the *volume* of the waters cannot change, either (assuming minimal volume expansion or contraction due to temperature changes). Is it possible for the space of our universe to expand while simultaneously maintaining a constant volume for the shell of water that bounds it? Frankly, I have a hard time visualizing such a scenario. But if the answer to that question is *no*, this would seem to rule out the possibility of an expanding universe.

Although Humphreys (1994a, 1994b) originally argued that an expanding universe was implied by Scripture, Hartnett (2011) has since argued that such an idea cannot legitimately be extracted from the text, as the Hebrew word for stretch does not really have connotations of elasticity as we know it. Humphreys now agrees with Hartnett that these verses should *not* be used as proof texts for an expanding universe (Hartnett, 2014). This consideration

might represent one more argument against an expanding universe, which in turn would require re-interpretation of the redshift data.

Do We Live in a Rotating Universe?

It could be significant that the waters were separated on Day 2 *after* God had already initiated the day/night cycle on Day 1. This suggests that the watery mass that would become the earth was *already spinning* at the time the waters were separated. But the "waters above" were part of these already-spinning waters. Hence, unless the Lord somehow "braked" the rotation of the "waters above" as He moved them to their new location, they still would have been rotating after God separated them from the waters below, and might presumably still be rotating even today. However, some degree of braking might be a physical necessity, given that a water molecule at the edge of the visible universe, moving with a rotational speed of one revolution per day, would have a tangential speed well in excess of the speed of light. If one assumes that the space of Heaven is the same as the space of our universe, then relativity theory would presumably apply in both our universe and Heaven. Hence, a watery shell rotating at such a speed does not seem possible. On the other hand, if relativity theory does *not* apply at the shell's location or beyond, it might still be possible for such a shell to rotate at such high speed.

A Watery Origin for the Heavenly Bodies?

Humphreys (1983, 1984) suggested that God used water to construct the heavenly bodies, and his model has been spectacularly successful at predicting the magnetic moments of bodies within our solar system (Humphreys 1986, 1990a, 1990b, 2008, 2012). I here offer one possible additional tidbit of information deduced from the text. Note that the physical topography of the earth (including the locations of the oceans and continents) was already established by the end of Day 3 (Genesis 1:9–13), but the heavenly bodies were not created until Day 4 (Genesis 1:14–19). Hence, *if* God did indeed use water that was created on Day 1 to make the heavenly bodies, then it seems this water *must* have been taken from the "waters above" rather than from the "waters below" for two reasons. First, by the end of Day 3, the earth simply would not contain enough water to construct all the heavenly bodies, as it then had the same approximate size that it does now. Second, even if the earth *did* contain that much water by the end of Day 3, the removal of that water likely would have destroyed the topography the Lord had already established on Day 3. Hence, if God used some of the water created on Day 1 to make the heavenly bodies, it seems that He *must* have taken this water from the "waters above." Presumably He would have "sliced off" part of the watery shell at universe's edge, making the shell thinner while still maintaining its symmetric, spherical shape, and then used the water in that "slice" to make the heavenly bodies. However, perhaps God did *not* use the Day 1 water to create the heavenly bodies, which seems to now be the position held by Humphreys (2008).

Possible Physical Problems

Earlier I presented a possible scriptural argument against an expanding universe. But if one assumes that the universe is not expanding, wouldn't gravitational collapse make the universe unstable? Wouldn't it eventually collapse in on itself? Perhaps. But such a collapse would take billions of years and is of no meaningful consequence in a universe that is only ~6,000 years old. Hartnett has noted that biblical creationists do not necessarily have to assume stability of large-scale structures in a young universe (Hartnett 2015).

Likewise, *if* one assumes that the "waters above" are spinning, then it seems that the shell would tend to fly apart due to "centrifugal force" (note to my fellow physicists: centrifugal force is in quotes!). Likewise, wouldn't the shell tend to flatten along the direction of the rotation axis?

These are issues that I don't necessarily know how to resolve from a physics perspective, but I am trying to derive as much information as possible from the biblical text, even though that information may sometimes raise additional questions.

In the following sections, I discuss some miscellaneous ideas that also could be relevant to constructing a biblical cosmology.

Other Possibilities: Is the Heavenly Mount Zion Located in a Northerly Direction?

A couple of Old Testament passages seem to suggest that the abode of God is associated with the direction north. Isaiah 14:12–3 describes Satan's boasting:

> How art thou fallen from heaven, O Lucifer, son of the morning! how art thou cut down to the ground, which didst weaken the nations! For thou hast said in thine heart, I will ascend into heaven, I will exalt my throne above the stars of God: *I will sit also upon the mount of the congregation, in the sides of the north*: I will ascend above the heights of the clouds; I will be like the most High. (emphasis mine)

Taken at face value, this passage seems to be saying that there is a heavenly mountain that serves as a place of meeting (or congregation) for the heavenly beings and that this heavenly mountain is in a northerly direction.

Another passage of Scripture seems to confirm this idea. Psalm 75:6–7 says this:

> For promotion cometh neither from the east, nor from the west, nor from the south. But God is the judge: he putteth down one, and setteth up another.

This is *very* interesting. The direction north is conspicuously absent by its omission in verse 6. If promotion does come from a direction, it must come from the direction north, as this is the only cardinal direction not excluded from the list. But the next verse makes it clear that it is God who puts down or sets up. Is this suggesting that the abode of God is in a northerly direction? It may also be significant that in Ezekiel's vision, Ezekiel saw his vision of God in a whirlwind coming from the north (Ezekiel 1:4).

Likewise, the whirlwind from which God spoke to Job may have come from a northerly direction as well:

> Fair weather cometh out of the north: with God is terrible majesty. (Job 37:22)

The word *zahab* translated "fair weather" is usually translated "gold" and is rendered "golden splendor" in most other translations. This verse seems to be saying that a golden splendor associated with God was coming from the north – which makes sense, since God begins speaking to Job in the very next chapter (Job 38:1).

But if the abode of God is associated with the direction north, this raises other questions: Does the direction north refer to the geographical north pole, or the magnetic north pole, since the two were "misaligned" by about 11° of latitude in 1995 (Hargreaves, 1995, p. 150)? This misalignment has decreased somewhat in more recent years but is still significant.

The first option seems more likely for several reasons. First, the location of the north geomagnetic pole has changed dramatically over the last several hundred years. Furthermore, although other cultures (such as the Greeks) may have possessed knowledge of magnetism by the time of Isaiah (Fowler, 1997), it is not clear that the Hebrews had such knowledge.

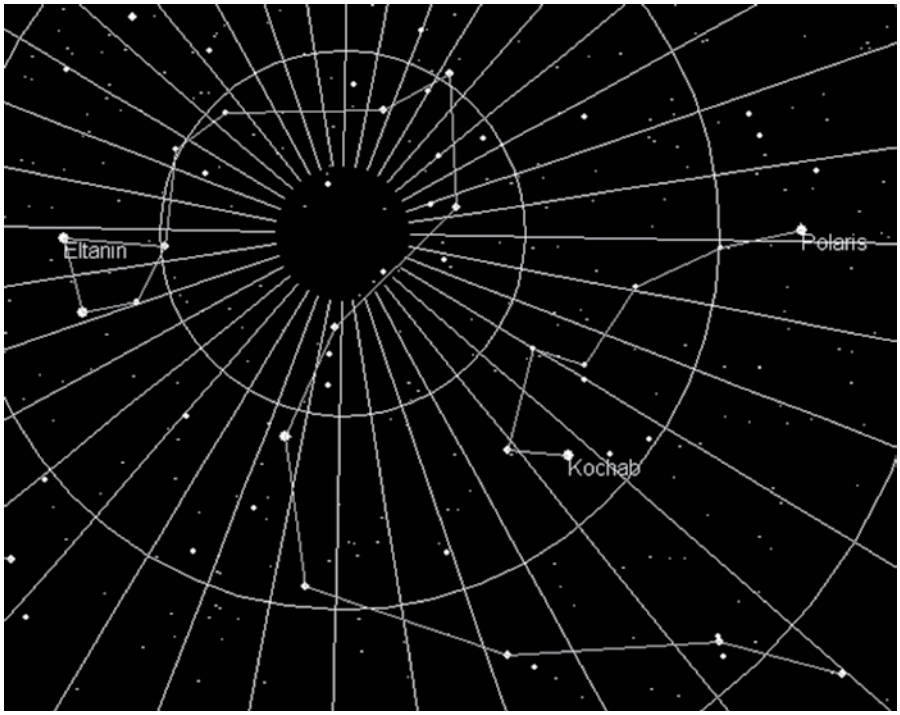

Figure 4. The constellation Draco encircles the North Pole of the Ecliptic. Image Credit: Tomruen, archived at Wikimedia Commons. Public domain.

This would mean that the "sides of the north" mentioned by Isaiah refers to geographical north, i.e., the direction along the earth's rotation axis. In other words, the "sides of the north" would presumably correspond to the north celestial pole. However, there is a complication. Torques applied to Earth's equator by tidal forces of the moon and the sun (and the other planets, especially Jupiter) cause the north celestial pole to precess slowly with a period of about 26,000 years (Cronin, 2010, p. 115) around the north pole of the ecliptic, which lies in a direction perpendicular to the plane of the earth's path around the sun. One could then perhaps argue that the direction north refers to the north pole of the ecliptic rather than the north celestial pole *per se*.

In either case, the heavenly mount of congregation would be in a generally northerly direction. This possibility is intriguing because, if true, it might provide additional evidence *against* the idea of a "gospel in the stars." Although the notion that the constellations depict a kind of primeval gospel message (similar to the prophecy in Genesis 3:15) in pictorial form has long been popularized by a number of authors (for example, Seiss, 1972), it has recently been strenuously criticized by Faulkner (2007, 2013). If it is indeed true that the heavenly mount of congregation is in a direction along either the north celestial pole or the north pole of the ecliptic, this might provide still another argument against this popular idea. The reason for this is that the constellation Draco (a dragon, or more specifically, a serpent), encircles the north pole of the ecliptic, which is (presumably) the location of this heavenly mountain (Figure 4). This would

seem very strange if the constellations were divinely ordained to describe the primeval gospel in pictorial form, as is often claimed. In that case, why would Draco, possibly representative of Satan, be encircling the (presumed) location of God's throne? Such a notion seems very inconsistent with the notion of a gospel in the stars, but it is very much consistent with Satan's prideful boast in Isaiah 14. Hence, if Isaiah 14:13 really is indicating that the heavenly Mount Zion is in a northerly direction, this might be evidence *against* a heavenly origin for the constellation names. It might even be positive evidence for a satanic origin for those names. However, it should also be noted that the constellations Hercules (in ancient times known as "the Kneeler") and Draco do indeed seem to depict the "crushing" of the serpent's head by the Messiah (Faulkner, 2013, p. 61), so perhaps there is some historical justification for the idea that ancient peoples used at least these two constellations to remind them of God's primeval promise of a coming Redeemer (Genesis 3:15). Even if that is the case, the odd location of the constellation Draco might be an argument that the constellation names were not divinely inspired.

Another intriguing passage that seems to suggest that the direction north is somehow spiritually significant is Psalm 48:1–2:

> Great is the Lord, and greatly to be praised in the city of our God, in the mountain of his holiness. Beautiful for situation, the joy of the whole earth, is mount Zion, on the sides of the north, the city of the great King.

Given that Jerusalem today is definitely *not* "the joy of the whole earth," the context of this psalm seems to be prophetic, describing the state of Mount Zion and Jerusalem after the Lord's return. (In this discussion, I am writing from a "premillennial" viewpoint that assumes a literal 1,000-year reign of Christ on Earth.) Interestingly, the passage seems to be saying that Mount Zion is "on the sides of the north." Taken literally, it would suggest that future Mount Zion will be located at the North Pole! Could this be a clue that during the geological upheaval of the end times, God will reorient the earth's rotational axis so that it passes through Jerusalem? We already know that the earth's topography will be significantly altered in the end times so that Mount Zion becomes the highest of all mountains (Isaiah 2:2; Ezekiel 40:2; Micah 4:1). Such a reorientation of the earth's rotational axis would imply that Jerusalem would be preeminent among the cities of the world in more ways than one.

Of course, this would seem to demand a much more temperate high-latitude climate than what we experience today. Yet biblical creation scholars have long speculated that something like this would indeed be the case (Morris, 1983, p. 409).

Of course, the above passage refers to the earthly Jerusalem, not the heavenly New Jerusalem. That is indeed true, but it would seem appropriate for both the earthly and heavenly Mount Zions to be aligned along the same rotational axis.

In fact, such a possibility might help to resolve a potentially puzzling feature of the New Jerusalem. However, some background is needed to "set up" the apparent problem. According to Scripture, the New Jerusalem is 12,000 furlongs (Greek *stadia*) on a side, as well as 12,000 furlongs high (Revelation 21:16). This would make the New Jerusalem about 1380 miles on a side, roughly half the length of the continental United States. Most commentators assume that the New Jerusalem will be cubical, rather than pyramidal in shape, since pyramidal structures are often associated with paganism. Also, a cubical shape would be consistent with the cubical shape of the holy of holies in Solomon's Temple (1 Kings 6:20; 2 Chronicles 3:8). The following discussion assumes that the New Jerusalem is indeed cubical in shape, although the actual shape of the New Jerusalem is not critical in this discussion.

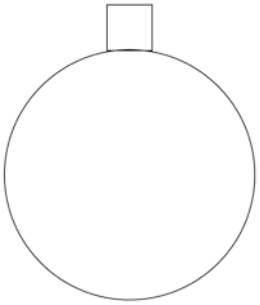

Figure 5a. Approximate size of (a presumably cubical) New Jerusalem relative to the size of the present-day Earth.

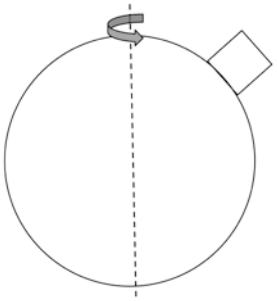

Figure 5b. The New Jerusalem, located off the Earth's rotational axis.

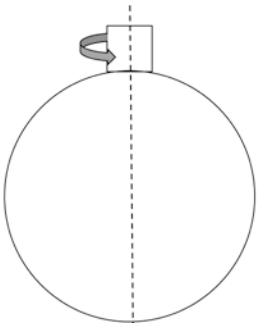

Figure 5c. The New Jerusalem, located on the Earth's rotational axis.

We do not know if the new earth will be the same size as the present Earth, but assuming that it is, the new

earth would have a radius of 3,959 miles. Hence, the height of the New Jerusalem would be 34.9% that of the earth's radius. Figure 5a shows the size of the New Jerusalem compared to that of the earth itself.

Although the New Jerusalem will not need the light of the sun or moon (Revelation 21:23), it may be that the new earth will still experience day and night due to rotation about an axis. We do know that months will still be measured in the eternal order, since the Tree of Life will yield fruit each month (Revelation 22:2). In fact, given that the tree has twelve "manner" of fruits and the fruit is yielded each month, it seems to suggest that there will be twelve months per year, even on the new earth. And if that is the case, there would likely be night and day.

And that is the root of the puzzling feature regarding the New Jerusalem. If the New Jerusalem were to be located "off" the (presumed) rotational axis of the new earth, then this would be very asymmetrical (Figure 5b). At a minimum, this would seem somewhat aesthetically displeasing and might even constitute a rotationally unstable situation, depending on the mass of the New Jerusalem. But if it were located on the new earth's rotational axis, then this would seem much more symmetrical and presumably more aesthetically pleasing (Figure 5c). But if this is to be the case for the New Jerusalem on the new earth, then it seems reasonable that it would also be the case for Jerusalem in the millennial kingdom. Hence, Jerusalem would be located at the North Pole during the millennium, which seems to be what Psalm 48:1–2 is saying.

The Tabernacle and the Temples: Hidden Cosmological Clues?

The Bible gives extremely detailed descriptions of the tabernacle (Exodus 25:1–31:11; 36:1–40:33), Solomon's Temple (1 Kings 6:1–8:9; 2 Chronicles 2:1–4:22), and even Ezekiel's Temple (Ezekiel 40:1–47:12). It is remarkable that the Bible spends much more time discussing these places of worship than even the Creation Week, the fall of man, or the Genesis Flood. Surely there is a reason for that!

Is it possible that these descriptions might also yield some important clues to constructing an accurate cosmology? Secular scientists would no doubt sneer at the notion of attempting to derive cosmological information from these passages of Scripture, but the Bible-believing cosmologist or astrophysicist cannot afford to overlook the possibility that the Lord may really have given us some such "hints" in these passages.

Conclusion

This article has mainly been an exercise in "thinking out loud" in hope of stimulating discussion on this issue. These are the kinds of questions and issues with which creation scientists must grapple if we are going to construct a truly biblical cosmology.

Acknowledgments

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Biblical Evidence for Time Dilation in the Cosmos

D. Russell Humphreys*

Abstract

Several Scriptures imply that at the end of this age, presumably not long from now, distant stars will be much older than we see them now. The time required for most stars to get old is many billions of years, yet that much aging must occur within the roughly 6,000 years the Bible says have elapsed on Earth since Creation. Cosmologies using Einstein's gravitational time dilation assert that clocks (and all physical processes) in the distant cosmos once ticked much faster than they did on Earth, so the above-mentioned Scriptures support those theories. But the Anisotropic Synchrony Convention (ASC) cosmology does not allow for time dilation, so the above-mentioned Scriptures are evidence against the ASC view.

Introduction

Creationists generally—or at least speaking for myself—have not paid much attention to what the Bible says about the stars in the future. After all, Creation was in the past, so what can Bible prophecy tell us about that? But Scripture tells us some spectacular things will happen in the heavens at the end of the age (cf. Matthew 24:3, 7, 13, 14; 28:20). All Scriptures here are from the NASB translation, and I have put some words in bold font for emphasis. I will take all scriptural passages (most of them here being prophetic) at face value, or straightforwardly, a method many people call "literal interpretation" (Humphreys, 1994). Appendix B outlines the history of various methods for interpreting prophecy.

Because events as great as those at the end of the age (such as Creation, the Flood, and the first coming of Christ) have happened within the past few thousand years, most of us would expect the end of this age to be less, perhaps much less, than a few thousand years into the future. Here are some verses describing the heavens at that time:

> And **the** stars of the sky fell to the earth, as a fig tree casts its unripe figs when shaken by a great wind. And the sky was split apart like a scroll when it is rolled up. (Revelation 6:13–14)

> **The** stars will fall from the sky, and the powers of the heavens will be shaken. (Matthew 24:29)

Many people assume this falling of stars is merely a large meteor shower. But the Greek word for star in these verses is *astēr*. In New Testament times it meant any bright point in the sky, whether meteor, planet, or what we today mean by a star (Bauer et al., 1979, p. 117). Notice the definite article ("the") I have put in bold font. It is there in the Greek of both passages. That implies that **all** the stars that exist at that time will fall. A parallel Old Testament passage I will quote more extensively below says explicitly, "**All** the host of the heaven … **all** their hosts … (Isaiah 34:4; "heaven" is plural, "heavens," in Hebrew)

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will participate in this action. For **all** the stars, even very distant ones, to be seen falling at one time by people on Earth is an extraordinary event.

Steve Miller, an amateur astronomer active in the Creation Research Society a few decades ago, and now with the Lord, believed that God will make (and had already made, he felt) it possible for people to see this starfall in real time, by making the speed of light nearly infinite. He convinced Danny Faulkner of that (I think) and after a few years, me also. In Appendix A I offer a possible way God may do that, by letting the light from a star falling out of the *fabric of space* travel very rapidly through the *hyperspace* that I think surrounds it (Humphreys, 2014, sections 1 and 3). From any place on Earth, we would perceive the direction of fall as downward, toward the earth. The Greek word translated "to" in Revelation 6:13, *eis*, which often denotes "simply direction toward someth[ing]." (Bauer et al., 1979, p. 228), so the text does not require that the falling stars actually reach the earth.

The Falling Stars Will Be Older Than What We See Now

The parallel passage (partly quoted above) to Revelation 6:13–14 is:

> And all the host of heaven will **wear away**,
> And the sky will be rolled up like a scroll;
> All their hosts will also **wither away**
> **As a leaf withers from the vine**,
> Or **as *one* withers from the fig tree**. (Isaiah 34:4)

This implies that the stars will have time to wear out and wither away. That time for most stars is many billions of years. Yet as we observe them now, distant spiral galaxies show only a few hundred million years' worth of rotation (Humphreys, 2005, item 1). Note that according to both conventional cosmology and time dilation cosmologies, we do not see the galaxies as they are at present but rather *as they were* billions of their years ago (in the case of very distant galaxies). That is because these cosmologies say it took that long for the light to travel to us. Any cosmology having a finite speed of light will have this *lookback time*. The next section will discuss and illustrate this point in more detail. According to my second cosmology, clocks on Earth would tick off hardly any time at all during most of those billions of years, so that as measured by clocks here, the time elapsed would be only 6,000 years or so. Here are several more Scriptures that suggest that more time has elapsed in the heavens than here on Earth:

> Of old Thou didst found the earth;
> And the heavens are the work of Thy hands.
> Even they will perish, but Thou dost endure;
> And all of them **will wear out like a garment**;
> Like clothing Thou wilt change them, and they will be changed. (Psalm 102:25–26)

> And, "Thou, Lord, in the beginning didst lay the foundation of the earth,
> And the heavens are the works of Thy hands;
> They will perish, but Thou remainest;
> And they all **will become old as a garment**." (Hebrews 1:10–11)

It is quite possible that this wearing-out applies not only to the heavenly bodies, but also to the heavens, to the fabric of space itself, as "like a garment" suggests. In the case of spiral galaxies, the ones greater than half a billion light-years away would, unseen to us, have wrapped themselves into smooth discs by now (assuming secular theories for the preservation of spiral arms continue to fail). Here is another verse that suggests that the heavens have already acquired great age before the present time:

> To Him who rides upon the highest heavens, which are from **ancient times** … (Psalm 68:33)

Of course, this is not ironclad proof, because the duration of "ancient times" is open to question.

Another verse that suggests that the heavens have experienced more days than Earth is:

> So I will establish his descendants **forever**,
> And his throne as the **days of heaven**. (Psalm 89:29)

Notice the comparison between "forever" and "the days of heaven." Even though Hebrews 1:11 and Psalm 102:25–26 (quoted above), and others (for example, Matthew 5:18) show that the present heavens will not last forever, God chooses to compare the eternal reign of David's descendant Christ with the "days of heaven," implying that there are many more of such days than there have been on Earth. There are alternative ways to understand the verses in Psalm 68 and 89 above, so they are not decisive proof of time dilation. But at first sight, they appear to support it.

Graph of a Time-Dilation Cosmology

To explain how time-dilation cosmologies would feature such aging of the heavens, I will outline my second one (Humphreys, 2008) as an example, without much explanation of the physics. Figure 1 is a graph showing how I presently imagine it. It follows the relativists' tradition of displaying the time axis vertically, rather than horizontally as an oscilloscope would. To clarify ideas for use in a later section, this graph uses the *Einstein Synchrony Convention* (ESC). Though Einstein was the first person to define it rigorously, the ESC is merely the way most people have *imagined* past, present, and future since the beginning. That is, they imagined events in the sky as happening "right now." Upon learning that light isn't infinitely fast, they revised their

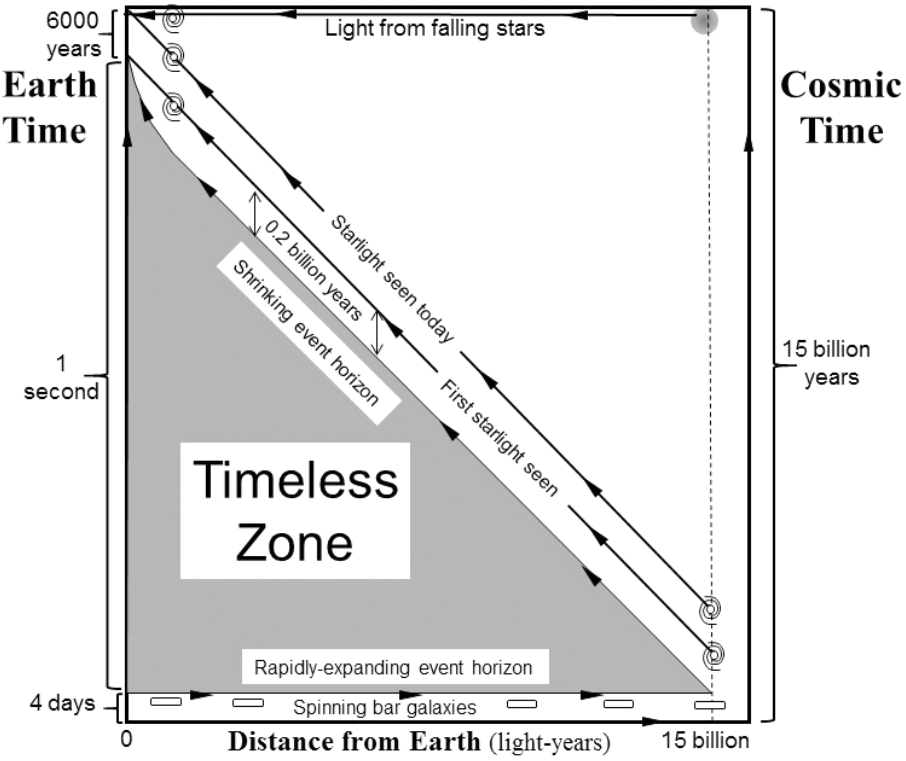

Figure 1. Space-time graph of latest version of Humphreys' second cosmology. Time is displayed using the Einstein Synchrony Convention (ESC). The Timeless Zone is a region in space-time where clocks (and time itself) tick very slowly. Note that the spiral galaxy moving up the dashed line on the right has turned into a smooth disc at the upper right.

thoughts about light travel but not their imagination of "now."

Events in the ESC's "present" would be what a very-long-range radar would show if its beam, both going and returning, were almost infinitely fast (relative to the rest frame of the fabric of space, which I think is the rest frame of the cosmic microwave background radiation [Humphreys 2014, section 5; Humphreys, 2002, end note 28]). Such a beam would be a horizontal line in Figure 1. The "ESC super-speed radar beams" in Figure 4 will show that line in more detail as two almost-horizontal lines, the going and returning beams.

The right-hand vertical axis is *cosmic time*, the time a real clock 15 billion light-years away would tick off. Imagine a network of nonphysical ideal clocks, clocks that time dilation would not affect, spread throughout space and synchronized (by the ESC) with the real clock at 15 billion light-years. At the present time the cosmic clocks would have ticked off 15 billion years.

Real clocks that are closer to us than 15 billion light-years would be stopped part of the time, so they would have ticked less than 15 billion years. But when they are ticking, they would be synchronized with the cosmic clocks. That would include Earth's clocks, the *Earth time* shown on the left-hand axis. Today, Earth's clocks would have ticked off only about 6,000 years since Creation, but by the ESC those years would encompass all the cosmic events shown on the right. That is, we could imagine a network throughout space of ideal clocks that tick (and don't tick) in unison with Earth's clocks, being synchronized by the ESC. By this "Earth Standard Time," the universe is only about 6,000 years old. Relativity demands that to specify how old something is, we must specify which clocks we are using.

I have arranged this graph so that light rays with speed *c* are straight lines at 45° angles to the axes. Everything is to scale except the regions labeled "6000 yrs" and "4 days," which I had to make large enough to be seen. The horizontal axis is distance away from Earth, in light-years.

The Timeless Zone

The triangular-shaded region in Figure 1 is what I call the *timeless zone* (Humphreys, 2008). In it, time is nearly at a standstill. Along the left vertical axis, I arbitrarily (to be specific for clarity) represent Earth's clocks as ticking off only one second during the billions of cosmic clock years Earth is in the timeless zone. This near timelessness is how I interpret the equations of Einstein's general relativity as applied to this situation, which is a relatively empty shell of mass, the "waters that are above the heavens" in Psalm 148:4. Though the shell of water (by now turned to ice particles and planet-sized balls of water covered with ice) is quite tenuous, its total mass has to be at least twenty times the total mass of the stars we can observe in the cosmos. This large mass has important results in general relativity, spelled out in my article (Humphreys, 2008). I arbitrarily (to be specific for clarity) place this shell at a distance of 15 billion light-years away from Earth, somewhat farther out than our telescopes can see.

The creation of the masses of the stars and galaxies causes (see Humphreys, 2008 for physics details) the timeless zone to come into existence early in the fourth ordinary-length day of

Creation. It begins as a small spherical zone of darkness surrounding the earth. I call the surface of the sphere the *event horizon*, because it is similar to the event horizon of a black hole. The differences are (1) the gravitational forces within the timeless zone are relatively small, whereas inside the event horizon of a conventional black hole the forces get very large toward the center; and (2) time within the event horizon in this situation is nearly at a standstill, whereas in a conventional black hole, time stops only at the event horizon but resumes as one passes within it.

In this new variation of my scenario, the event horizon expands outward very rapidly, much faster than the speed of light, out to the shell of waters. The event horizon is a simply a boundary that marks where the fabric of space is at a certain critical level of gravitational potential (energy per unit mass). The horizon is not a material object, so it is not limited by the speed of light. The graph shows its expansion outward as a horizontal line, the bottom edge of the shaded triangle, just above the section labeled as the first four days of Creation. Just below that edge I show some newly created galaxies as bars of stars, whose mass brought the timeless zone into existence. The bars are spinning at creation, but they nearly stop spinning after the timeless zone engulfs them, because there is very little time for physical processes to take place in that zone. Later, after they emerge again from the timeless zone, they resume spinning, and after a few hundred million years of their time will turn into spiral-shaped galaxies.

How Starlight Got Here

Shortly after the event horizon expands out to the shell of waters, it turns around and begins shrinking at roughly the speed of light. My 2008 paper explains how tension in the fabric of space would cause the timeless zone to shrink. A recent DVD (*Light Years? No Problem!* 2016) may help the nontechnical reader to understand this and other things in the 2008 paper, which was peer-reviewed and technical. In this variation of the scenario, the tension would cause negligible expansion of the fabric of space. The redshifts of light from the galaxies would be caused by changes in gravitational potential, not expansion (Humphreys, 2008, eq. 21). The top of the shaded triangle shows the inward path of the event horizon. Notice that in most places its slope is close to 45° relative to the axes, indicating that its speed is close to the speed of light. As the event horizon shrinks, it uncovers galaxies (Figure 2). They resume emitting light, some of which follows the event horizon inward. Eventually the event horizon shrinks to zero radius, revealing the earth. The light that has been following the timeless zone inward then reaches Earth. The graph shows the path of the light as a line, or light ray, pointing toward Earth at exactly 45°. Later light rays are parallel to but slightly above the first ray. The last light ray reaches Earth at the present, 6000 years after the first light ray to arrive.

To the right of the 6000-year light ray, galaxies exist, their present form unseen by us. Those galaxies continue to age. A galaxy 15 billion light-years away from us would have aged 15 billion years by the present time. It is that aging to which I think Isaiah 34:4 refers.

Notice that the top-left edge of the timeless zone curves upward a little, indicating that the event horizon slows down below the speed of light as it approaches Earth. Previous events in Creation week offer a simple physical cause for the slowdown, but that is a detail I hope to explain in another paper. Some

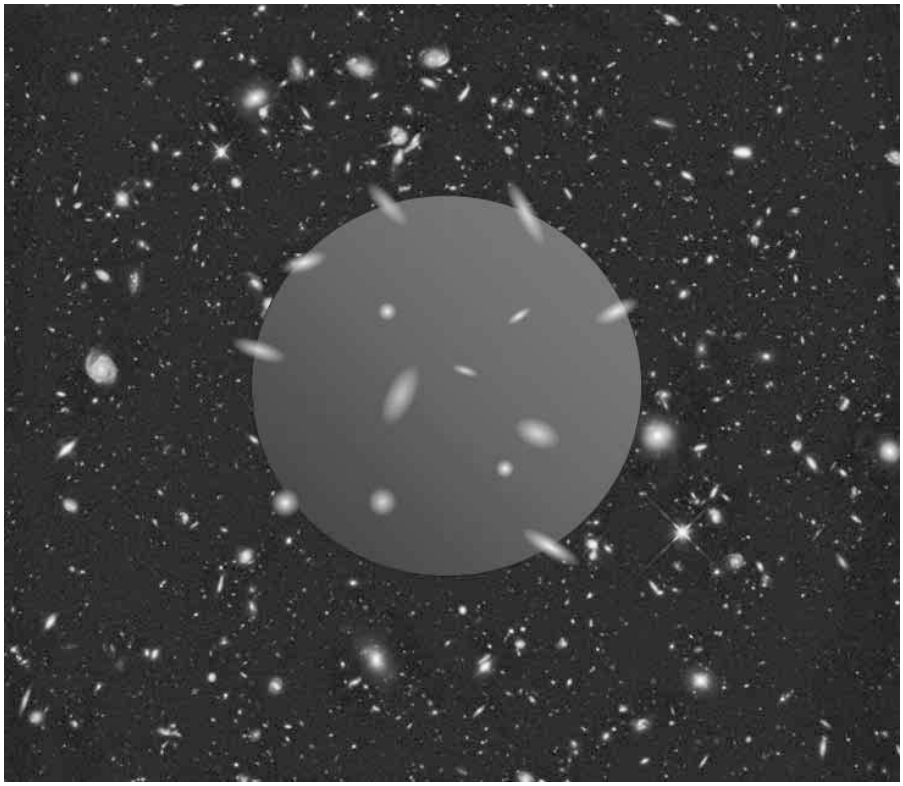

Figure 2. Light from emerging galaxies follows the shrinking spherical event horizon inward. For everything within the event horizon, including the earth at its center, time has almost stopped.

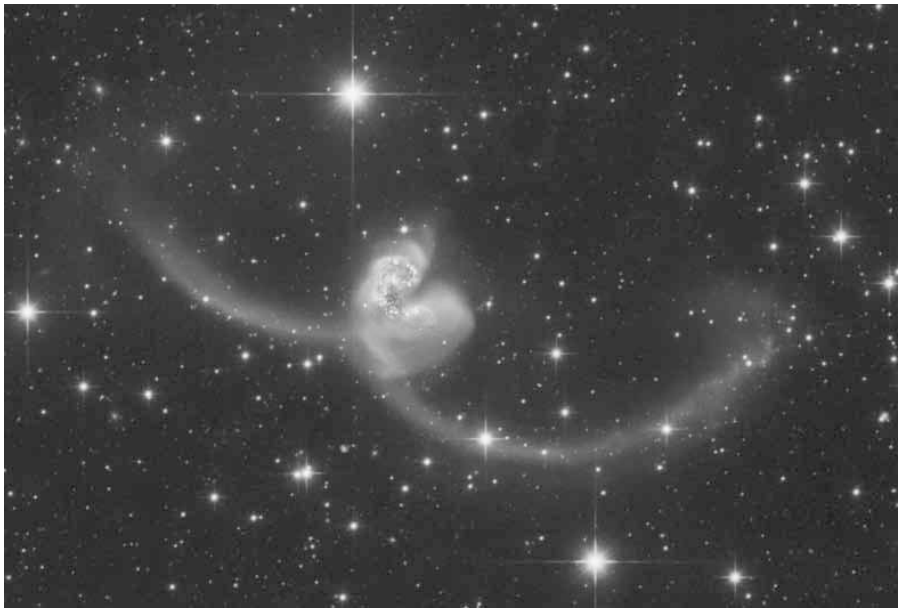

Figure 3. The "Antennae" galaxies are evidence for time dilation. Simulations show this structure would result from a collision of two normal galaxies lasting a few million years of their time, after which the images we see started on their way to us.

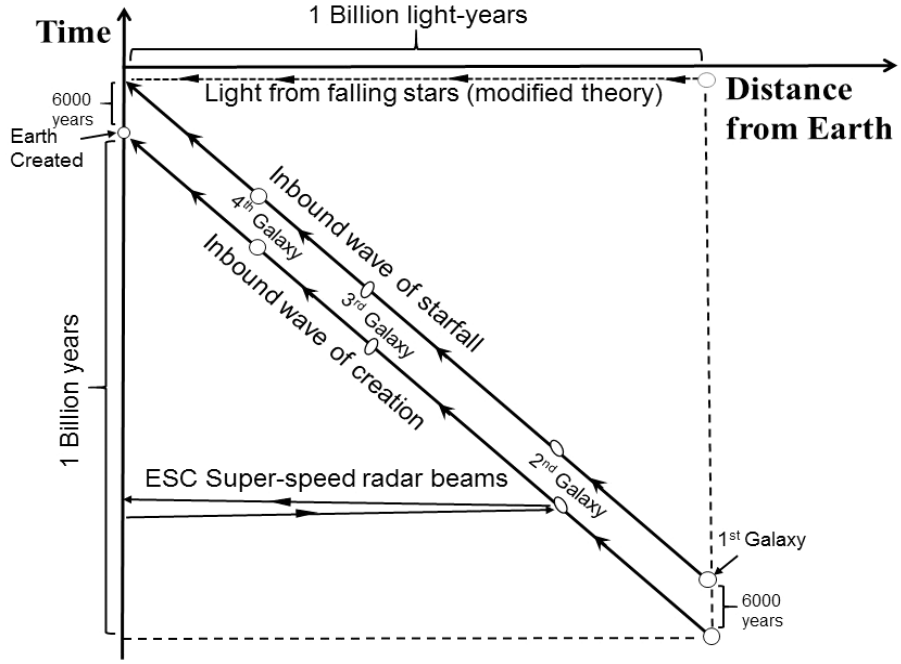

Figure 4. Lisle's cosmology seen using the Einstein Synchrony Convention (ESC) to display time. The "ESC super-speed radar beams" illustrate a way to give (in the location Earth would exist later) the time of creation of the second galaxy, about 0.75 billion years ago according to the ESC view of time. The Lisle cosmology says that God created Galaxies 1–4 in succession in a wave traveling inward at the speed of light. That way, the first light from each galaxy would arrive at Earth simultaneously with the others on the fourth day after the earth's creation.

of the earliest light rays from galaxies catch up with the event horizon and slow to a crawl within it. The upward curve makes a gap between the first light ray reaching Earth and the upper edge of the timeless zone to the right of the upward curve. That allows some cosmic time to elapse for the galaxies before the light we see from them started out toward us. A few hundred million years could elapse, giving differential rotation a chance to turn bar-shaped spinning galaxies into the spiral galaxies we now observe. There are a few other observations suggesting that millions of years of cosmic time elapsed for some astronomical objects before the first light we see from them had started on its journey toward Earth. An example is the "Antennae" galaxies (Figure 3), which simulations suggest are the result of the collision of two galaxies lasting several million years. It is evidence that time dilation occurred even before the images we see started toward us.

"Aged Heavens" Scriptures Versus ASC

Figure 4 shows the Anisotropic Synchrony Convention (ASC) cosmology proposed by Jason Lisle (Newton, 2001; Lisle, 2010). For ease of general understanding, the figure depicts that cosmology using the Einstein Synchrony Convention (ESC), the conventional way to think of past, present, and future, which I described above in the second section. Lisle has said this is an acceptable way to present his view (Newton, 2001), though many of his supporters have not understood that. The "ESC super-speed radar beams" (see second section) shown are nearly horizontal, reflecting their almost infinite speed. This ESC view of the Lisle cosmology shows the creation of the galaxies as an inward-moving spherical wave, a thin shell of creation, starting billions of years ago and billions of light-years away. The shell would converge upon the earth

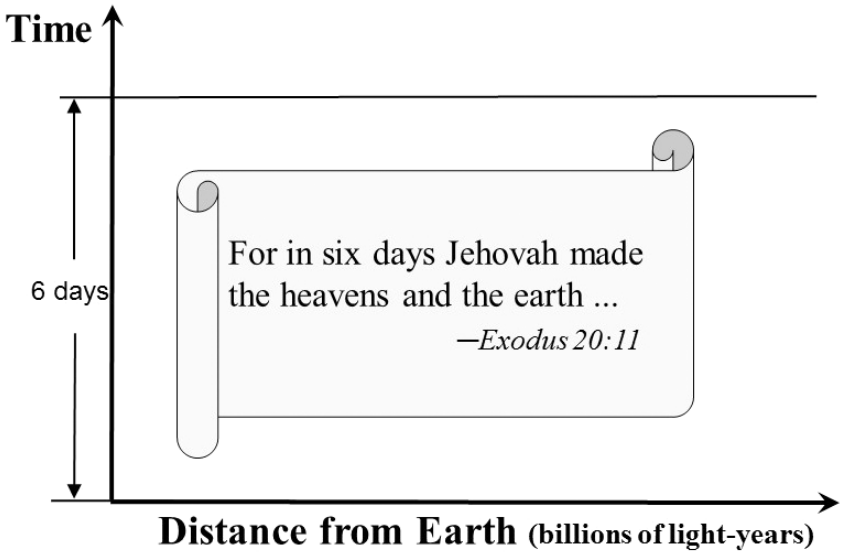

Figure 5. Biblical evidence suggests that God uses the Einstein Synchrony Convention (ESC) in Exodus 20:11, excluding the Lisle cosmology and requiring time dilation to make the stars old at the end of this age.

during the fourth ordinary-length day of creation about 6,000 years ago.

Lisle asserts that God used the ASC when He declared that He made the whole universe in six ordinary-length weekdays about 6,000 years ago. God would have dated (or "time-stamped") the entirety of each light ray by the time of its arrival upon Earth. In other words, if God were using the ASC, He would regard "now" or "the present," as being *all along* the sloped trajectory of light traveling to us in Figure 4.

Let us consider how the Lisle cosmology must deal with the *end* of the heavens. It has to have the stars in each galaxy being destroyed (falling and fading out) about 6,000 years after the creation of that galaxy. There would be a spherical wave of destruction converging upon the earth, reaching it during the end of this age. People at that time would observe all the stars disappearing at about the same time.

But that scenario doesn't allow any time dilation between the birth and death of each galaxy. The spiral galaxies would have to have been created in their currently observed shapes, and the "antennae" galaxies would have to have been created in the rather peculiar shape we now observe. None of the stars or galaxies seen at the end of the age would appear to have aged more than 6,000 years, contrary to the star-aging verses above. Thus, those verses are evidence against the ASC cosmology.

There is a way one could modify the Lisle cosmology to allow the stars to age. We could allow the galaxies on the "inbound wave of starfall" line to continue to exist (and continue to age) but somehow stop their light from reaching Earth when they are above that line. Then we could draw the horizontal dashed line, labeled "light from falling stars (modified theory)." That light ray would travel infinitely fast to Earth, allowing people at the end of the age to see the stars aged and falling. The main problem with this modified theory is that it has God using two implied definitions of "now," one all along the rays of slope 45° representing light reaching us at speed *c*, the other all along the horizontal ray representing light reaching us at infinite speed. The second definition takes away the plausibility of the first. It would be more consistent to simply have the ESC and time dilation.

Discussion and Conclusion

The Scriptures in the first two sections imply that the stars observed on Earth during the end of this age will be aged more than how we now see them. That supports some creation cosmologies and weighs against others. Figure 1 shows how time dilation with the ESC would allow accelerated aging of distant stars while much less time was elapsing on Earth. This implies that God used the ESC in Scriptures like this:

> For in six days the LORD made the heavens and the earth. (Exodus 20:11)

Figure 5 shows the six days of Creation as being bounded by horizontal lines (ESC) extending throughout the universe. That is, the six days would elapse simultaneously (in the ESC sense) everywhere in the cosmos.

Figure 5 completely disagrees with the Lisle cosmology in Figure 4. The latter does not allow time dilation, so the Scriptures for aging in the heavens in the first two sections are evidence against it and against the ASC used to justify it. It appears that God's view of the past, present, and future is exactly how humans have thought of them since the beginning of the cosmos. God was using the Einstein Synchrony Convention (ESC) long before Einstein lent his name to this rather commonsense view of time.

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Appendix A: How People Could See the Stars Fall

Figure 6 shows a cross-section of the fabric of space in the vicinity of the earth. The vertical axis, labeled *w*, is the fourth spatial dimension (not time) that Scripture implies (Humphreys, 2014, section 3). The fabric is very thin in the *w*-direction, and so are masses such as the earth and stars, which are constrained to stay within the fabric but can move freely horizontally (in the *x*, *y*, or *z* directions) through it. I call the 4-dimensional volume above and below the fabric *hyperspace* (Humphreys, 2014, section 3), a term that has reentered physics in the last few decades (Kaku, 1994).

In my article (Humphreys, 2008, section 5 and end note 27), I discuss the optical properties of the fabric of space and hyperspace. The fabric must be exceedingly transparent in the horizontal direction, because light from very distant stars has traveled through it to us without much attenuation. I suggested that light can travel through hyperspace much faster than light traveling horizontally through the fabric at speed *c*. Then, under normal conditions, light emitted from stars within the fabric would suffer *total internal reflection* (see optics textbooks) and be prevented from leaving the fabric. Instead, it would be channeled horizontally through the fabric like light in a *single-mode* optical fiber (Jones, 1988). This reflection at the top and bottom edges of the fabric could be also what constrains matter from leaving the fabric under normal conditions, or there could be some other constraint. Last, under these conditions, light and matter from hyperspace would similarly be prevented from entering the fabric.

However, there appear to be times when the above is not true. Scripture mentions a number of occasions[1] when the heavens have been or will be "opened," often clearly physically (not metaphorically or in a vision), with light and matter going to and from Earth through the openings. One passage that strongly implies such an opening is directly associated with the events in the heavens at the end of the age:

> The sun became black as sackcloth *made* of hair, and the whole moon became like blood; and the stars of the sky fell to the earth … And the sky was **split apart** like a scroll when it is rolled up … and they said to the mountains and to the rocks, "Fall on us and **hide** us from the presence [lit. "face"] of Him who sits on the throne." (Revelation 6:12–16)

It appears that these people can see the face of God and are fearful because they see that He is seeing them. This and many other Scriptures (e.g., Psalm 102:19) imply that the third heaven (2 Corinthians 12:2–4), where the throne of God is, is in some unusual way above the earth, and not far from us. I suggest that it is within seeing distance in the fourth spatial direction, which we would perceive as upward. On this and the other "heavens opened" occasions, the normal barriers to light and matter moving in the *w*-direction, to and from hyperspace, seem to have been removed.

Removal of the barriers, even if only partially in places, would have four major consequences for the heavens:

[1] Genesis 7:11; 2 Kings 7:2, 19; Psalm 78:23; Ezekiel 1:1; Malachi 3:10; Matthew 3:16; Mark 1:10; Luke 3:21; John 1:51; Acts 7:56; Revelation 19:11.

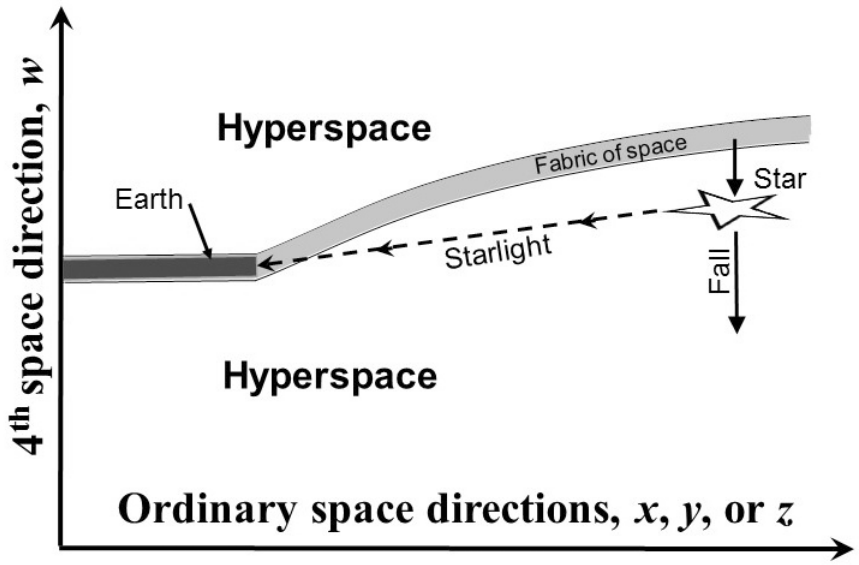

Figure 6. Cross section of the fabric of space, showing how falling stars could be seen almost immediately on Earth. The vertical direction, labeled w, is the fourth spatial dimension (not time) described in Humphreys (2014, section 3). The starlight travels very rapidly through hyperspace, entering the fabric of space just before it reaches Earth.

1. Light from stars moving toward us within the fabric of space would tend to leak out into hyperspace, as light leaks out of an optical fiber when we damage its cladding (Jones, 1988, p. 112). That would attenuate light reaching us by the normal path from the heavenly bodies (sun, moon, and stars), making them darker, as several Scriptures say, such as this one referring to the end of this age:

   > The sun and moon grow **dark**,
   > And the stars **lose their brightness**. (Joel 3:15)

2. Consider the barriers constraining matter to movement only in the *x*, *y*, or *z* directions within the fabric of space. According to my explanation of gravity, the fabric of space is being enormously accelerated upward in the *w*-direction (Humphreys, 2014, section 4). If, in the regions where the stars are, God completely removes from the lower surface of the fabric the constraint to *w*-motion, then the inertia of the stars would make them fall out of the fabric down into hyperspace, as Figure 6 shows.
3. The release of the great weight of the stars would let the fabric of space bounce upward and fall back downward. That would make great waves in the fabric of space that could be seen (via hyperspace) on earth while some stars are still in the fabric:

   > But immediately after the tribulation of those days the sun will be darkened, and the moon will not give its light, and the stars will fall from the sky, and the powers of **the heavens** will be **shaken**. (Matthew 24:29)

   > Yet once more I will **shake** not only the earth, but also **the heaven**. (Hebrews 12:26)

   This is apparently also the time when most of the fabric of space, except for the region around the solar system, will be rolled up like a scroll or mantle (Isaiah 34:4; Hebrews 1:12; Revelation 6:14). Such rolling-up could also produce waves in the fabric of space.
4. The large speed of light in hyperspace would cause the atoms in the falling stars to emit greatly blueshifted light in their rest frame. But as seen from the fabric's frame, the falling stars would quickly accelerate to a speed close to the speed of light in hyperspace. That means velocity time dilation would produce a great redshift that would tend to compensate the emission blueshift, putting the light back into the visible wavelengths. Then the light would travel very fast through hyperspace until it reaches the fabric of space not far above the earth's surface. Because God has reduced the effectiveness of the reflecting barrier in that region, the light can enter the fabric of space, allowing people on Earth to see it.

I suggest that God has designed all these factors to show people great signs in the heavens at the end of the age. The stars darken while great waves in the heavens shake them. Then they fall, "as a fig tree casts its unripe figs when shaken by a great wind" (Revelation 6:13). After the starfall, there will be complete darkness in the stellar heavens beyond a darkened sun and a darkened, reddened moon. It will be a terrifying sight, causing "men [to be] fainting from fear," Christ said (Luke 21:26).

Appendix B: Outline of the History of Interpretation

Some young-earth creationists are from theological traditions that interpret historical passages such as Genesis

literally but prophetic passages nonliterally. Thus, they might be inclined to dismiss the Scriptures I offer as being merely poetic allegories that have nothing to do with physical reality. Many of these brethren are under the mistaken impression that the practice of reading prophecy straightforwardly started only recently in the nineteenth century. However, understanding prophecy literally was the normal view in rabbinical commentaries before the time of Christ, in the New Testament, and in commentaries by the early church fathers.

In his comprehensive book on the major systems of prophecy, *Things to Come*, Dwight Pentecost (1958) began by showing that the systems differ because of their differences in interpreting Bible prophecy. His second chapter is a well-documented study of the history of interpretation. I will merely touch upon some results of his study here.

First, Pentecost shows that the original method of interpretation of the Old Testament by Jewish teachers before the time of Christ was markedly literal. He states, "It must be concluded, in spite of all the fallacies of the Rabbinism of the Jews, that they followed a literal method of interpretation" (p. 17).

Next, he documents that Jesus Christ and the New Testament writers uniformly interpreted the Old Testament literally. The only seeming exception to that is in Galatians 4:24, where Paul makes an allegorical application of events recorded in Genesis chapters 17 and 18. It is clear, however, that Paul is basing his allegory on events he regards as historical. That is, he is interpreting the Genesis chapters literally.

Third, Pentecost shows that many of the church fathers before the fourth century interpreted the Bible literally. The main exception was Origen, who introduced the allegorical method of interpreting Scripture. At the beginning of the fifth century, Augustine was following Origen's allegorical method, and Augustine was profoundly influential in passing it on to the church of the Middle Ages. The Roman Catholic Church of today largely continues to use the method.

In the sixteenth century, the Reformers Luther and Calvin rejected the Roman church teaching on the gospel, but unfortunately, they continued to hold many of the other doctrines they had been taught in their youth, especially those of Augustine and the allegorical interpretation of prophetic Scriptures. Many of the mainline churches today that are tied closely to the Reformation still teach the allegorical interpretation of prophecy. Even before the nineteenth century, however, many conservative Protestant churches began returning to the original method of understanding Scripture, literal interpretation.

Letters to the Editor

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Comments on the Big Horn Basin

I would like to comment on the article by Mike Oard, "The Bighorn Basin, Wyoming—Monument to the Flood, Part I: The Flooding Stage" (*Creation Research Society Quarterly* 53:206–216).

Oard uses "Walker's biblical geological model," fleshing it out with examples from the Grand Canyon to the Bighorn Basin. The application uses the labels of Walker's: "flooding stage" and "retreating stage." In Figure 1, I chart Oard's timing of the Flood events from comments in the article.

Oard summarizes the model: "Walker… concluded that after an initial rapid rise, the Genesis Flood continued to rise at a slower rate before it peaked and began to abate. At first, because of its depth, the abating water flowed freely, with few if any obstacles to impede its rush to sinking ocean basins. As the water continued to subside, land features were exposed, gradually forcing the flow into channels. As with the flash flood, the final stage ended with rivers and streams flowing down their newly excavated paths" (p. 208).

Like the graph (Figure 1) Oard's model shows a "flooding stage" having a rapid rise of the water level attaining the maximum just prior to the 150th day and a steady "retreating stage." He doesn't express it, but the quote and the diagram would be interpreted that the rapid rise was maintained globally until just prior to the ark grounded on the 150th day.

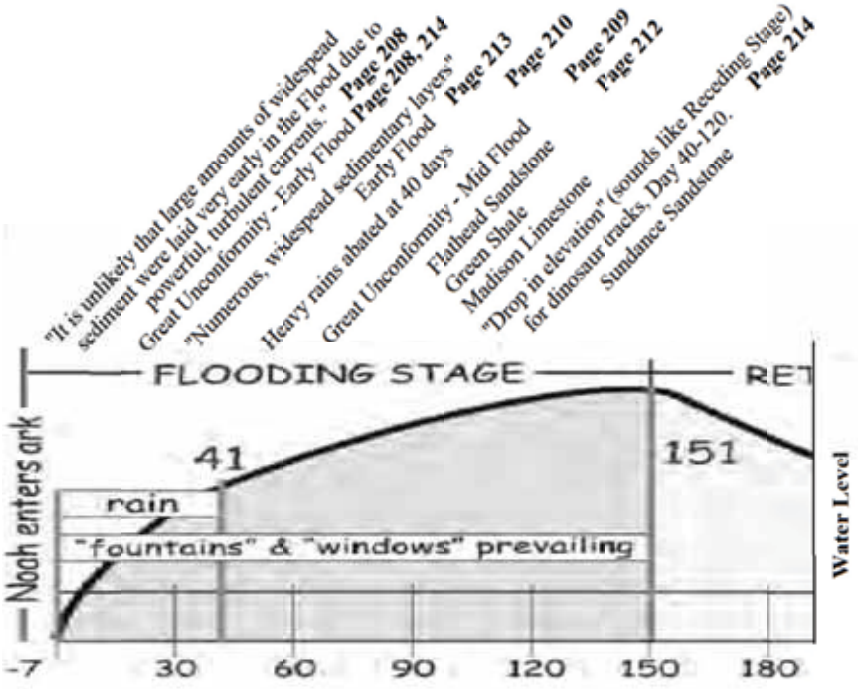

Figure 1. Summary of Oard's points about timing of the Flood events.

But, is this a reasonable hydrodynamic expectation with the timing he uses for the rest of the events?

He speaks of "few if any obstacles to impede its rush to sinking ocean basin." Oard wants to start the sedimentary deposits with the ocean basin. But in our limited knowledge of the sea floor, it isn't crusted with layers of sedimentary strata like the continents. The present deep ocean basins are the largest area of our globe that is not full of sediments. The abyss has very little sediment capping the crystalline crust, but by contrast the continental shelf, when explored extensively, contains strata that are continuous with the continents. For instance, the Gulf of Mexico is floored with Jurassic deposit that reaches up to Oklahoma, and that is consistent with the North Sea Basin and most of the Australian coast. If the sinking of the ocean basins happened at the start of the Flood, it is reasonable to expect significant sediment in the ocean basins as we see across the continent; and if the sinking happened later, why do we not see soft sediment warping or other indication of motion of already deposited sediment? But we do not.

For simplicity, I will refer to the erosional boundary below the Great Unconformity as the *Greatest* Unconformity. In the Grand Canyon the two unconformities are separated by the Sixty-mile Formation, Chuar Group, Nankoweep Formation, and Unkar Group, with a combined mapped depth of about 13,000 feet (400 m); this is a greater deposition than the Tonto Group above the Great Unconformity. Both major unconformities planed off crys-

talline basement rock with sedimentary rock, suggesting the two unconformities represent a comparable erosional event. Hydrodynamics would say it had to be similar energy expenditure, separated by depositional events not unlike the Tonto Group of the Grand Canyon. This would necessitate a minimum of two energy surges, with time between them to deposit the equivalent of the Tapeats to the Muave, about 30–45 days' work, based on Oard's time from Great Unconformity to Tapeats. I don't see these two time periods reflected in the model.

When did these two unconformities take place? Oard expresses some confusion when he attributes them to both early Flood (p, 208, 214) and mid-Flood (p. 209). This may seem a small difference, but how much later did the sedimentary strata occur? The Flathead Sandstone, the Green Shale, and the Madison Limestone, equivalent in the Bighorn Basin for formations in the Grand Canyon, preceded the Grand Staircase and the Sundance Sandstone, where the dinosaur footprints are nearer the retreating stage of the Flood (p. 211).

If two erosional events happened with the hydrodynamics energy to each plane the entire globe off, it would impact the vertebrate population. Considering a specific dinosaur, if the water rapidly rises to drowning depth on its way to an energy level to create a planation surface over the globe, this would require that to survive the dinosaur would need to swim and stay suspended in highly turbulent water during the two erosional events, the Greatest and Great Unconformities, and their included sedimentary layers. According to Oard's timeline, the dinosaur would make its impression on the fossil record some 60 to 90 days later. Oard proposes his BEDS (Briefly Exposed Dilivial Sediments) as an explanation for the occurrence of tracks and bone beds, but it does not provide the refugio to keep the survivor alive to the date when it can leave its mark. This is a long enough time span that I would question the dinosaur's ability to get enough food to maintain life IF a physical refugio did exist.

Oard may not understand the hydrodynamics of deposition. He says, "It is unlikely that large amounts of widespread sediment were laid very early in the Flood due to powerful, turbulent currents" (p. 208). The hydrodynamic interpretation of the Tapeats (Barnhart, 2012a, 2012b) determined that deposition occurred from a shallow hyperconcentrated *turbulent* flow. Thus, sediment can deposit under turbulent conditions; moreover, it is required in the interpretation of the Tapeats. And for depth of flow, the hydrodynamics require only a few meters at a maximum for the thicker strata, and the study of the footprints atop the Tapeats (Barnhart, 2014) determined it had to be less than 0.5 meters intermittantly. This is not high water as Oard portrays in early or mid-Flood.

I want to encourage authors of Flood models to take the whole information about the hydrodynamics of the rock record into account. Maybe we need to center our thinking on a limited number of events that occurred in specific areas repeatedly over the globe instead of limited events occurring globally.

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For a better understanding of the Flood,

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Response to Barnhart

I welcome feedback from my articles and thank W. R. Barnhart for his interest. It gives me the chance to clarify what may have been confusing and the chance to correct misunderstandings.

The diagram representing the rise and fall of the Floodwater (my Figure 2 in Oard, 2017) and Barnhart's Figure 1 in his letter) is meant to be just a schematic of the *average* rise over the globe with time. I could have displayed a steeper rise in the first 40 days and a flatter rise between Days 41 and 150. The earth was not completely covered with water until the peak of the Flood, about Day 150. Before that, some areas were inundated early on and others later. Some areas were briefly and repeatedly exposed. These provided a short respite for dinosaurs, as well as the mammals, birds, and other organisms as they desperately tried to avoid the encroaching Floodwater. These short-lived islands were covered and exposed until near the peak of the Flood. This leads us to the fact that the Flood was much more complicated than a simple rise and fall of the water. There were many variables that acted upon the Floodwaters. These include the constantly changing land/sea configuration, the depth of the Floodwater, the path of the currents, the varying velocity and turbulence of the Floodwater, impacts, tectonics, volcanism, etc.

To clear up a misunderstanding, the ocean basins did not sink until later in the Flood. Significant sinking did not take place until the retreating stage. The sinking caused a continental erosional event removing the top layers of the previously deposited sediments (maybe averaging 500 m). This sediment was deposited on the continental margin, with some of the clay carried farther out. The phrase that Barnhart emphasizes, "few if any obstacles to impede its rush to sinking ocean basin," was preceded by "it peaked and began to abate. At first, because of its depth, the *abating water* flowed freely, with few if any obstacles to impede its rush to sinking ocean basins" (emphasis added). This was the early part of the retreating stage of the Flood.

Barnhart then goes on to make the point that the ocean basins have little sediment and that some of the flooding stage sediment, such as the Jurassic in Oklahoma, is continuous with the Jurassic that floors the Gulf of Mexico basin. Do we really know whether these sediments, labeled Jurassic are continuous between Oklahoma and the Gulf of Mexico? Maybe the Jurassic of Oklahoma does not mean the same as the Jurassic in the Gulf of Mexico. Regardless, even if they are the same, I would expect some sediments deposited along the continental margin during the flooding stage that would occupy the bottom of the sediment pile. However, it is well known that much of the margin sediments start as a thin taper, generally in the coastal area, and thicken seaward, which would fit well within the retreating stage of the Flood. Barnhart points out, similar to other creation scientists, that the sedimentary rocks are almost all on the continents, which is one reason why I lean toward the view that the continents and oceans switched during the Flood.

Barnhart points out the two unconformities in the Grand Canyon. The "Greatest Unconformity" is observed only in limited areas below thick Precambrian sedimentary rocks. The Great Unconformity then planes igneous and metamorphic rocks and these gently tilted, thick Precambrian sedimentary rocks. Forming more than one unconformity in an area does not seem like a problem since the very early Flood (for instance, the first 40 days) would have had variable turbulence and very fast currents in areas. This would fit well the IVT (impact/vertical tectonics) model of the Flood, which both of us believe. However, so far I am convinced the number of impacts was more likely in the thousands rather than a billion or so. The Great Unconformity indicates tremendous erosion occurred over a large area of at least the western United States. It is an exhumed erosion surface in Wyoming as discussed in my article, exposed by late Flood erosion. (It is possible that the Great Unconformity was not continuous or the same unconformity over the western United States but represents very early Flood planing over relatively large areas.)

When Flood currents slowed down, to at least the upper flow regime in hydrodynamics, then deposition would occur. In referring to these Grand Canyon unconformities, Barnhart says, "If two erosional events happened with the hydrodynamics energy to each plane the entire globe off, it would impact the vertebrate population." Global planing is an exaggeration of my position. The hypothesis of briefly exposed diluvial sediments (BEDS) would contradict global planing.

Yes, it is possible to deposit sediments under turbulent conditions, such as in the upper flow regime (probably less than 10 m/sec) and below. If current speeds are greater than about 10 m/sec, maybe occasionally greater than 50 m/sec, the substrate should mainly be eroded. The Tapeats has multiple cross-beds deposited between the lower and upper flow regimes with a modest amount of turbulence. I would not be surprised if the Tapeats was primarily a result of hyperconcentrated flows, but the flow depths that Barnhart gives are questionable. The impressions Barnhart points out in the Tapeats Sandstone (Barnhart, 2014) are far from proved to be eroded tracks, which he used to support his proposition that occasional subaerial exposures and very shallow water depositions occurred in the Tapeats Sandstone.

For more information on the details of the Flood in relation to geology, including what we can and cannot know about the pre-Flood earth and what the Flood produced afterward, namely the Ice Age, see *How Noah's Flood Shaped the Earth* (Oard and Reed, 2017).

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Michael J. Oard

Mis-understanding Genesis 1

I read with interest George P. Drake's letter to the editor in the Summer 2016 issue and primarily agree with his appraisal of the chapter [Genesis 1] and his way of expressing the material, except for a couple places which I think are important enough to point out. While I do not expect Mr. Drake to reply or change his stance, I do believe it is important to make you aware of these differences.

Mr. Drake states, "Genesis 1:1 and 2:1 form a solid literary unit called an *inclusion*.... Everything in between these two verses is what happened *in the beginning*." I would agree that the two statements are all-inclusive of the majority of the creation but are not a summary of the chapter in between but rather the first and final steps in the narrative of what happened. I am not a linguist, so I will leave that to Mr. Drake and others, but I reason that if Creation is an *ex nihilo* act as I believe, and "*made* and *formed*" are not *ex nihilo* acts, then the three different words must be used in different places to draw the distinction between the three acts of creation and the remaining acts of God's making and forming hands. (I have always suspected one of the two words, "made" and "formed," referred to the making of something as in a craft, weaving a cloth or embroidering a curtain, or what we often refer to as "creative acts," while the other referred to assembling, as in assembling an engine or piece of furniture.)

The second and third uses of the word "created" come in verses 21 and 27. "And God created great whales, and every living creature that moveth" and "So God created man in his own image, in the image of God created he him." These are two distinct acts *ex nihilo* just as Genesis 1:1 is, and they create the two remaining substances/things that were not included in the very instance of beginning. Animals have a "breath" in their nostrils that separates them from the merely material portions of creation, and God included at least part of them on the ark with man. And, man has the "breath of life," which gives him moral responsibility and separates him from the rest of the animals. I refer to the two additional substances as "soul/ breath" and "spirit" respectively, although I recognize both of these words have gained other cultural usage that clouds this meaning.

This separation clarifies the meaning of the text differently than your closing statement: "But if God formed Adam from the dust of the ground and breathed life into him, it seems to mean He did at least one act of creation using starting material He had already created." To me, it means God formed man's body but then created/imparted into that body a living soul. Two distinctly different acts that mean "God formed man" is not a summary statement, just as "God created" in 1:1 is not merely a summary statement.

If we view creation as an *ex nihilo* act, then two things are in creation that were not there in 1:1, and I believe that recognition forms the basis of understanding the three different hierarchical levels of God's creation. In stating, "The life is in the blood," God recognizes a basic difference to the existence of animals that is distinct from other living cellular organisms. If a plant kills a man, as in a tree falling on him, it is not to be destroyed as an animal that kills a man is required to be (Genesis 9:5, 6 shows the distinct separation).

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Time: Digging Deeper

I am thankful for the two letters in the Summer 2016 Quarterly dealing with the time problem, because the letters have kept this subject alive. I welcome the opportunity to respond to these letters and to Dr. Faulkner's critiques. I want to dig deeper into this important issue, because the evidence I presented in the first letter was too cursory. If that evidence had been given in greater detail, the thesis I'm proposing would have been more convincing. This letter will dig deeper and explain better that evidence. It will show the prevailing convictions about time are not correct. But it will also propose a resolution to this issue.

The Two Letters

Several subjects of Mr. Drake's and Mr. Dobberpuhl's critiques are addressed in this letter. However, their primary subjects are as follows:

- Mr. Drake maintains that the ancients disregarded the details of sequences and progress. This assertion is the basis of the philosophy of his critique. However, the Creation account refutes that assertion: God knew mankind wanted—and needed—to know those sequential creation details.
- Mr. Dobberpuhl maintains that the primeval cosmos and earth consisted of "as-yet unknown … material." That is, the earth and the cosmos did not originally consist of our ordinary atomic matter but of "a mysterious … material." This theory is woven throughout his critique.
- The existence of such inexplicable material is extremely doubtful. Based on this concept, his critique does not have merit, because the subject of Genesis 1:2 is our ordinary water.

Respecting the Evidence

Creation theories need to recognize and explain correctly the physical facts, i.e., not forcing the physical evidence to support incorrect interpretations of the Word. The following are examples of phenomena where, to conform to prevailing scriptural interpretations of time, the present physical theories are in error.

Evidence of glacially buried trees at Two Creeks, Wisconsin, is dismissed because the evidence supposedly contradicts the Word. (The average age of those trees was about 60 years, and one tree lived 142 years.) Concerning the trees, consider this glacial sequence: first, the development, and then the advance, and then the recession of the Michigan lobe, and then the development of a forest on its glacial till, and then the advance of the Green Bay lobe, whose till finally buried the forest. Each of these sequences consumed many years. These physical facts negate the popular 350-year interpretation of Genesis 11:10–26.

The time-consuming magnitude of the glacial epoch is diminished. But, based on ten measurements taken over a 20-year span (see below) reveal sea levels at the glacial epoch maximum averaged about 450 feet lower than today's level. With at least 200 vertical feet of ocean water remaining as ice on Greenland and the Antarctic, at the glacial epoch maximum the post-Flood sea level dropped about 650 feet. With such an enormous volume of water, many years were required for the glaciers to develop into their maximum size (18 million square miles of ice at one mile thick) and then to atrophy into their present (30%) state.

The evidence of mature, limestone caves, 400 feet below sea level is dismissed, because lowering the seas and then forming the caves required too much time.

Thousands of till-filled drumlins in Wisconsin are dismissed as insignificant. But time was required, first to develop the till, then to recess the glacier, and then to advance the glacier over that till to form those beautifully shaped, till-filled drumlins.

These events required considerably more time than 350 years. When "dismissing" is done in ignorance and with good intentions, it is still not right. For creation apologetics to succeed, it must acknowledge and correctly explain the evidence.

Catastrophic Plate Tectonics

Other glacial phenomena are dismissed to make the evidence conform to the prevailing time interpretations of the Word. For example, two geology books (see below), though based on the uniformitarian time frame, clearly show that an immense glacier existed on an Africa-South America connected landmass. Much of plate tectonic theory is valid. But this southern glacial evidence negates the prevailing catastrophic plate tectonics theory. A young-earth theory is needed that will explain these physical phenomena.

The Young Universe Policy

Because of past harmful theories, the CRS directors "established a policy of publishing articles that support a young earth, young universe creation model only." Supporting the "young earth" model was scientifically and biblically necessary. However, the "young universe" policy was unwise, because it requires rejecting the meaning of the Word. Moreover, the policy rejects an abundance of physical evidence, as I will explain.

Genesis reveals the reality of God and that He is the source of all physical reality. In His love God made these realities easy for us to understand. Therefore, His Creation revelation is not complex: the first verse simply states God brought the cosmos into existence, i.e., that He created (*bara*) the cosmos from nothing, including this planet, Earth. This initial

Table I. Sea levels at the Glacial Epoch Maximum vs. today's level.

Magazine	Date	Page	Feet down
Science	1-27-95	536	- 420' 436'
Science	5-29-09	1186	- 482' 426'
Science	8-7-09	711	- 436' 475'
Science	2-12-10	790	- 426'
Science	6-25-10	1152	- 420'
Science	3-13-15	1237	- 460'
Nature	11-23-06	404	- 492'
			Average - 447.3'

statement explains where the earth, described in verse 2, came from.

However, the CRS policy requires that the first verse serves only as an introduction; because of the supposed creation of light on the first day and the cosmos on the fourth day, the first verse only summarizes the Creation account rather than reveals the creation of the cosmos before the first day. If being an introduction is the sole function of the first verse, no clear statement exists in Scripture concerning when the earth was created. Moreover, the description of the earth in verse 2 assumes the earth existed. But because verse 2 cannot use the revelation of the earth's creation as stated in verse 1, this restriction makes verse 2 inapt and strange.

Before continuing to critique the CRS policy, additional facts concerning the darkness described in verse 2 are necessary. The darkness of verse 2 is a darkness of the earth's surface. Elaborating on that darkness, Job 38:9 states, "I made the clouds its garment and wrapped it in thick darkness" (NIV). This cloud-darkness relationship indicates the clouds produced the darkness; without the clouds, light would have shown on its surface—which, on the first day, it finally did. These phenomena clearly indicate the existence of sunlight.

Concerning the CRS policy, if the first verse does not proclaim the cosmos's creation, several other problems develop:

1. If the sun did not exist, how were the first days demarcated; what produced the phenomena of "day and night"?
2. If the sun did not exist, what was the source of the light "created" on the first day?
3. Verse 2 states that mass existed. If mass existed, a source of light already existed. The supposed "creation" of light would therefore have been sequentially inaccurate.
4. The young-universe policy requires that the cosmos began on the fourth day. This neces-sary interpretation forces the development of strained theories, theories that try to harmonize that cosmos with the real world.

Asah, Natan

Those without the knowledge of the flexibility of the Hebrew words *asah* and *nathan* will probably maintain that Genesis 1:16 insists the cosmos was "made" (*asah*) on the fourth day, and furthermore that Genesis 1:17 insists the cosmos was "placed" (*nathan*) also on that day. In the 2016 letter, this language issue was discussed in detail. That discussion showed that other, valid meanings of these two words do not require the doctrine that the sun, moon, and stars began their existence on the fourth day.

Dr. Faulkner's Critiques

Several subjects of Dr. Faulkner's 2016 critiques have been addressed above. But three subjects remain: his concerns about creation during the fourth day; the interpretation of Exodus 20:11 (and 31:17); and mountain building during the Ice Age.

Dr. Faulkner questions my thesis concerning the fourth day, i.e., that my thesis maintains nothing material was created that day and therefore is contrary to the Word. In response, consider the creative sequence: It consisted of both a material and an immaterial creation. The immaterial creation consisted of modifying, separating, and working on the material that already existed, while the material creation created new material. In general, the creative sequence consisted of first forming what existed and then filling what was formed with new material. So, the immaterial aspects of the creation sequence were necessary.

The immaterial aspect applied to the fourth day. The cosmic "establishments" of that day were important for the world in which mankind would live; e.g., their ordering of time. The fourth day of the creative six-day sequence was needed.

Dr. Faulkner maintains the general statement of Exodus 20:11 refutes my thesis. However, a reasonable translation of *asah* (using valid words; e.g., "established") supports my thesis. The fourth day was indeed a creative day.

Concerning mountain building, Dr. Faulkner maintains that "most mountain building had finished by the ice age." However, consider the following:

Diastrophism

The Pleistocene, also called the "Glacial Epoch" and the "Ice Age," was the post-Flood glacial, orogenic period. Many geologists assert its diastrophism was very unusual:

> The Pleistocene indeed witnessed earth-movements on a considerable, even catastrophic scale. There is evidence that it created mountains … of

> a size previously unequalled. … The Pleistocene indeed represents one of the crescendo in the earth's tectonic history. (Charlesworth, 1957)
>
> Mountain uplifts amounting to many thousands of feet have occurred within the Pleistocene epoch itself. (Flint, 1947)
>
> Pleistocene diastrophism is perhaps the greatest and most widespread that the earth has known since Pre-Cambrian times. (von Engeln et. al.,1952)
>
> It is remarkable that mountains in many parts of the globe, all characterized by rapid [Pleistocene] uplift after a period of rapid planation should occur in so many different tectonic styles. … Why should a near-global pulse of mountain building take so many different forms? … We do not yet know what causes this short, sharp period of uplift. (Ollier et. al., 2000)

The Glacial Epoch's relationship to the Pleistocene's period of mountain building was determined by the deformation of contiguous continental glacial remains; because the glaciers developed first, the original, horizontal glacial debris, e.g., moraines, striae, etc., were subsequently deformed by the mountain-building forces. Charlesworth comments on this evidence:

> Faulting, uplift and crustal warping have been proved for almost all quarters of the globe. Faults … have been observed in many countries traversing glaciated rock-surfaces, drifts, tills, moraines, outwash faces, loess, varved clays, etc. (Charlesworth, 1957)

The glacial, geologic evidence reveals mountain building occurred during the glacial epoch.

The Age of the Cosmos

The heavens are wonderful beyond words. They continually increase my awe and reverence and love of our Heavenly Father. How did He do it? The "big bang" theory is impossible. Furthermore, in leaving God out of the picture, most scientists resort to implausible explanations for the origin of the cosmos. But the Word provides the answer: When God began these mass-energy phenomena we do not know, but He did. Because many astronomy theories are built on theories, the prevailing claims of immense distances and incredible timescales are questionable. May our creation astronomers discover valid explanations!

A Telescopic Interpretation of Genesis 11

Genesis 11 gives, from the Flood through nine ancestors, the genealogy of Abraham. Each ancestor had children, and each child began a lineage. The birthdates specified which of the children began the nine Abrahamic lineages, while each lineage *forefathered* its succeeding ancestor. (The Hebrew verb *yalad* also means "forefathered," i.e., became the progenitor of.) Together, the nine lineages, each of unknown length, created a telescopic genealogy. Therefore, the length of the Flood-to-Abraham interval is not known.

Conclusion

God created the universe and then, only thousands of years ago, in six days God created life and mankind on this planet, Earth. This assertion is biblically sound. Also, the physical evidence proves that Genesis 11:10–26 is a telescopic genealogy encompassing an unknown period of time.

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Universal Expansion and Longevity: A Response to Glatt

I would like to start my response by thanking Mr. Glatt for his paper on life span decay (Glatt, 2016). The discussion of the history of study on this matter was extensive and the author's note interesting. I also found his comparison of the decrease in longevity to a step decrease in a capacitor interesting and novel, though I am not sure I agree with it at this point. I would certainly encourage Glatt to continue his work, and I do not want my criticisms to douse his enthusiasm or interest.

That being said, there are several serious problems I want to address. For simplicity, I will break these down into three categories: expansion of the universe, longevity equation calculations, and additional miscellany. Each of these points will be summarized at the end of my response for clarity.

Expansion of the Universe at the Time of the Flood

Glatt (2016, pp. 170–171) cited Russell Humphreys' idea about the expansion of the universe at the time of the Flood, an idea that is certainly fascinating. Glatt suggests that the factor of expansion was 90,000 and that this change in distance is what caused the change in longevity between the pre-Flood and post-Flood worlds. There are two main problems with this idea: the mechanism doesn't work, and even if it did, it wouldn't do what Glatt wants it to do.

Let's look at the factor first. In neither his book *Starlight and Time*, nor his section in the *Radioisotopes and the Age of the Earth* volume 1 (Vardiman et al., 2000) did Humphreys give a value for the expansion he suggested, at least not for the Flood (he did discuss numbers related to the possible expansion during the Creation week but not the expansion during the Flood). Unless I have missed something, the 90,000 factor seems to be original to Glatt. (I am not criticizing the idea of the universe expanding at the time of the Flood—that is a separate matter. It is this massive 90,000 factor that I am critiquing.)

So, what would this 90,000 factor mean? I asked a friend of mine who is familiar with astronomical matters about this. Having not had a chance to read Glatt's paper, he asked to remain anonymous but did give me permission to print this observation he made:

"[D]o I understand correctly then that we could take today's distance to a star, divide by 90,000, and get the pre-Flood distance? That would put Proxima Centauri within our solar system. Its center would be closer to Earth than Jupiter ever gets today."

In fact, it gets worse. If we use the distance between the sun and Neptune, multiply that by 90,000, and convert that to light-years, we get this:

$$(2.7962 \times 10^{9} \times 90{,}000) / (5.8785 \times 10^{12}) = 42.81 \text{ light-years}$$

This means that all stars within 42.81 light-years would, under Glatt's model, have been as close or closer to the sun than Neptune. Not just Proxima and Alpha Centauri but dozens of stars would have been inside our solar system.

But it gets even worse than that. Proxima Centauri is the closest star to Earth today (other than our sun, of course) at approximately 4 light-years away. Wikipedia is not an authoritative source, but I will use distances from Wikipedia to do back-of-the-envelope calculations here (see Table I for numbers and specific sources). The Milky Way is given a maximum diameter of 180,000 light-years, so if we divide by 90,000, that would mean the entire Milky Way would be crunched into a maximum of 2 light-years, half the current distance to the nearest star.

But let's look at what Glatt said: "Moving the stars (galaxies) 90,000 times closer…" (p. 171).

This makes it unclear if Glatt meant all the stars, or only meant this factor should be applied outside our galaxy. So, let's assume that the Milky Way stars were unchanged and that this factor applied only to galaxies outside our own.

Outside our galaxy is the Local Group, which includes the Andromeda, Triangulum, and NGC 3109 galaxies, among others. For comparison, the modern distance from Earth to the center of our Milky Way galaxy is estimated at about 27,000 light-years and from Earth to the star Arcturus is about 36.7 light-years. Using Glatt's 90,000 factor, NGC 3109, the farthest galaxy in the Local Group, would be only 46.67 light-years from Earth. If we decrease their distance by a factor of 90,000, all the galaxies in the Local Group would actually be inside the Milky Way!

But it gets worse. Beyond the Local Group is the Virgo Supercluster. One of the farthest objects in the Virgo Supercluster is NGC 5023 at 26.1 million light-years away. Using Glatt's 90,000 factor, NGC 5023 would be only 290 light-years away. So, if Glatt's theory is true, not only would the entire Local Group be in the Milky Way, so would the entire Virgo Supercluster!

And still more distant stars and galaxies would be moved within the Milky Way galaxy under Glatt's model, but I think the point is made. How would multiple galaxies worth of stars get ripped out of the Milky Way without catastrophically destroying the stars, planets, spiral arms, or other structures?

Glatt's solution might be to propose some amount of telescoping, where the nearby stars moved only a little, with the amount of change increasing the farther out one goes. He is free to suggest such a thing if he wishes, but I don't know that it would help.

Table I. Comparison of modern distance and Glatt's proposed 1/90,000th pre-Flood distance for various objects.

Object	Modern Distance	Source	Glatt's 1/90,000th Distance
SOLAR SYSTEM			
Neptune	2.8 x10^9 miles	https://en.wikipedia.org/wiki/Neptune	31,111 miles
MILKY WAY			
Proxima Centauri (star)	4 ly	https://en.wikipedia.org/wiki/Proxima_Centauri	2.6 x 10^8 miles
Arcturus (star)	36.7 ly	https://en.wikipedia.org/wiki/Arcturus	2.397 x 10^9 miles
Milky Way center	27,000 ly	https://en.wikipedia.org/wiki/Milky_Way	0.3 ly
Milky Way diameter	180,000 ly	https://en.wikipedia.org/wiki/Milky_Way	2 ly
LOCAL GROUP			
Andromeda galaxy	2.5 million ly	https://en.wikipedia.org/wiki/Andromeda_Galaxy	27.78 ly
Triangulum galaxy	3.07 million ly	https://en.wikipedia.org/wiki/Triangulum_Galaxy	34.1 ly
NGC 3109	4.2 million ly	https://en.wikipedia.org/wiki/NGC_3109	46.67 ly
VIRGO SUPERCLUSTER			
NGC 5023	26.1 million ly	https://en.wikipedia.org/wiki/NGC_5023	290 ly

But from where did Glatt get the idea of 90,000? Let's check the rest of that quote: "Moving the stars (galaxies) 90,000 times closer … creates an 80° F universe, i.e., Caribbean" (p. 171).

In other words, if he had gone higher, the temperature would have been too great. (Glatt even acknowledges at the top of Figure 4 on page 172 that if the stars were 1 million times closer, space would be 5,264° F.) But I suggest that his 80° F universe is still too hot. Glatt's model increases the temperature of space by hundreds of degrees—such an increase would not merely warm the earth; it would broil it.

To summarize this section, Glatt's mechanism of having the stars and galaxies 90,000 times closer before the Flood would put numerous stars inside our solar system, or alternatively put numerous galaxies inside of the Milky Way, and there certainly would be no way to have them removed without major disruptions. Furthermore, the increased temperature would be devastating to life on Earth.

Equation for the Decrease in Longevity

Glatt gave an equation, first given in the paper's abstract (p. 165) and again on page 173, for the decrease of life span after the Flood of $L = 6664 \times e^{-dob/\tau}$, where *dob* is the date of birth "since Adam" (presumably meaning "since Adam's creation"; similar unclear wording occurs on pp. 168, 172, and 173) and τ is given the value of 563. With all the visuals already included, it would have been nice if the results in the analysis section on page 171 had been presented in a table format, but that's only a minor concern, considering that Glatt seemed to give numbers that don't match his equation (see the next section for more).

Table II lists proposed longevity equations, presented here in the Y=X format for ease of comparison. (For some sources, multiple equations were provided based on different approaches or sources. I have given preference to Masoretic-based equations and selected the equations that matched the data with the highest correlation.) Table III contains on the left the names of the patriarchs from Noah to Joseph with their ages at death. Moving to the right, one finds the values each equation produces for each person. Note also the very bottom row. This is the correlation. The equations are ordered left to right by this correlation.

Note that Glatt's equation produces 0.9284 correlation, but it is not the best. It is superior to the equations provided by Strickling, Brown, and Holladay. However, Dillow's equation was superior to Glatt's (0.9335). A basic logarithmic regression provides an equation that is 0.9647 correlated, over 0.035 greater correlation than Glatt's equation. But the best equation I have found to date for a person-by-person number is by Sanford et al. and corre-

Table II. List of longevity equations.

Source	Equation (Y = X format)	Variable Definition
Sanford et al, 2014	$Y = 1064.7\ (x^{-0.766})$	X = generation number, Noah = 1
Logarithmic regression	$Y = 846.2894287 - 289.3885909\ln x$	X = generation number, Noah = 1
Dillow, 1978	$Y = 652e^{-0.136x}$	X = generation number, Noah = 0
Glatt, 2016	$Y = 6664e^{(-x/\ 563)}$	X = year of birth since creation, Noah = 1056
Holladay, 2016	$Y = 386.6835e^{-0.00462214x} + 70.6508$	X = years since the Flood, Arphaxad = 2
Strickling, 1973	$Y = 925e^{-x/225}$	X = years since the Flood, Arphaxad = 2
Brown, 1974	$Y = 283e^{(-x/720)}$	X = years since the Flood, Arphaxad = 2

lates at 0.9725, almost 0.065 more than Glatt's equation.

In summary, Glatt's equation is not the most correlated. Out of the seven equations compared here, his ranks fourth.

Miscellaneous

I was somewhat disappointed in the numerical mistakes that were made. For example, on page 168, Glatt says that Noah was 602 when Methuselah died and the Flood came, but anyone who is familiar with Genesis knows that the Flood came when Noah was 600, not 602: "In the six hundredth year of Noah's life" (Genesis 7:11). I hope this was only a typo. Similarly, on page 167, Glatt says antediluvian life spans were ~950 years, but on page 168 he says ~900 years. Such inconsistencies should have been addressed before publication.

More troubling, Glatt's numbers on page 171 don't seem to match his equation. For example, he gives these results:

"Noah (1056, 950 [1023]); Shem (1558, 600 [420]); Arpachshad (1659, 438 [351])."

The format is year of birth, actual age, Glatt's equation's predicted age for each person. But when I put 1056 into Glatt's equation, I get 1021.28, not 1023. For Shem, I put in 1558 and get 418.70 (although I think Shem should be put down as being born in 1559, which would give 417.96). And for Arphaxad, 1659 gives 349.94, not 351. See Table III for the results I got when I ran Glatt's equation, and compare it to his string of results on page 171. The only thing I can think is that for some reason Glatt subtracted 1 or 2 from the year of birth—for example, using 1055 for Noah instead of 1056 yields 1023.09, and 1556 for Shem instead of 1558 yields 420.19, much more in line with the results Glatt reported. Subtracting 1 from each of the people's years of birth yielded numbers that would round to Glatt's answers, except for Shem, Salah (aka Shelah), Eber, and Serug, for which I had to subtract 2. I would very much like to read Glatt's explanation for how he did his calculations.

I also believe Glatt is mistaken about the 120 years in Genesis 6:3 (p. 174). This verse does not mean humans would be limited to a life span of 120 years or, as Glatt suggests, that it was tapering down to that. This verse seems to me to indicate that God was giving Noah 120 years' warning of the Flood's coming. Note that for more than 10 generations after God spoke to Noah, the people lived past 120 years, so a limit on life span cannot be what is meant.

Glatt also presented equations on page 168 arguing that the earth is 7500 years old and the universe was 8078 years old and then stated, "The anomaly is that these work out closely to uniformitarian standard ages." It's puzzling how this could be an anomaly, since the uniformitarian standard ages were what Glatt used to do these calculations in the first place. Furthermore, the biblical timeline, when laid out, comes to just over 6000 years, not 7500 or 8078 (Ussher, 2003; Jones, 2005).

Glatt also states that there were two divisions of humanity: "Two known macro population divisions took place during [the Genesis patriarchs'] lineage: first with Noah's sons and second at the tower of Babel" (p. 167). But what is the evidence for this? The division of Noah's sons couldn't have been that great, since it seems all their descendents were gathered at Babel at the time of that division, roughly 100 years after the Flood ended (Genesis 11:6 says "And the LORD said, Behold, the people is one…" and Genesis 11:9 says that the punishment on Babel confounded "the language of all the earth").

The speculation about Methuselah's name (p. 168, citing Brown 2008, p. 381) regards the Flood coming in the same year Methuselah died, while Glatt seems to imply this refers to a shortening of longevity being sent. I would argue that the Flood caused severe environmental changes that affected longevity, so it is not a coincidence that they occurred at the same time—rather, Methuselah's

Table III. Comparison of longevity equation results.

Source		Sanford et al, 2014	Logarithmic regression	Dillow, 1978, p. 27	Glatt, 2016, p. 173	Holladay, 2016, p. 260	Strickling, 1973, p. 151	Brown, 1974 p. 132
Noah	950	1064.7	846.29	652	1021.28	N/A	N/A	N/A
Shem	600	626.09	645.7	569.09	417.96	N/A	N/A	N/A
Arphaxad	438	458.94	528.36	496.73	349.94	453.78	916.81	282.21
Salah	433	368.17	445.11	433.57	328.85	396.55	784.74	268.82
Eber	464	310.32	380.54	378.44	311.78	354.35	686.78	257.85
Peleg	239	269.88	327.77	330.31	293.51	313.09	590.46	245.96
Reu	239	239.82	283.17	288.31	278.28	281.70	516.76	235.92
Serug	230	216.5	244.52	251.65	282.91	252.69	448.25	225.67
Nahor	148	197.82	210.44	219.65	249.26	229.12	392.30	216.46
Terah	205	182.49	179.94	191.72	236.75	209.24	344.86	207.91
Abram	175	169.64	152.37	167.34	187.93	146.64	193.51	173.57
Isaac	180	158.7	127.19	146.06	157.35	118.52	124.08	151.06
Jacob	147	149.26	104.02	127.49	141.44	106.92	95.03	138.98
Joseph	110	141.02	82.58	111.28	122.06	94.47	63.42	122.48
Correlation		0.9725	0.9647	0.9335	0.9284	0.8946	0.8922	0.8264

name foreshadowed the Flood, and the Flood caused the decline.

Glatt also seems to imply that the increased radiation after the Flood may have been from deuterium (p. 168). However, the decrease in longevity is just as likely to have come from increased radiation affecting the earth, either from the weakened magnetic field, loss of the firmament, or other sources. Even if radiation were the cause, increased Carbon-14 production in the atmosphere, increased ingestion of Potassium-40 from post-Flood plants, and exposure to radioactive elements in the earth's crust seem as likely a cause as deuterium, perhaps more so considering that deuterium is not radioactive.

Finally, the last odd statement made by Glatt that I will address is that people are "evaporating" (p. 169), and he cited the research of Azbel' that "more body atoms (bigger animals) leads to greater life span" (p. 169). Glatt labeled the evaporation idea as speculation, so I don't want to be too hard on him here, but let's think about this for a moment. If this were true, then obese people would regularly outlive skinny people. Furthermore, if body size were proportionate to life span, then blue whales ought to live for thousands of years, since they are many times more massive than we humans are. But that isn't the case.

In summary, Glatt's paper contained several miscellaneous errors and some odd statements.

On a positive note, oxygen metabolism is suggested as a possible cause for damage to the body and ultimately decreased life span (p. 169). It may be of interest that Dr. Cuozzo summarized some evidences showing ancient enzymes were more efficient than modern ones (Cuozzo, 1998, p. 268), which may have allowed for more efficient repair of free radical damage in the past.

Response Summary

Much has been said. To summarize the major points of my response:

- Glatt's idea of moving the stars 90,000 times farther away during the Flood is unworkable at all levels where calculations were done and would devastate life on Earth if true.
- His equation for post-Flood decrease of longevity is not the most accurate equation that has been proposed.
- His paper contained miscellaneous errors and odd statements.

Now I do want to stress that I thought there were several very good aspects of Glatt's paper—I especially find the comparison of life span decrease to a step decrease of a capacitor interesting and

worthy of further investigation. I wish to repeat that I do not want my criticisms to douse Glatt's enthusiasm or interest, and I look forward to reading his response.

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Brock Lee
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Response to Brock Lee

I welcome Brock Lee's letter as an opportunity to clarify a few things. The factor of 90,000 was indeed original to my paper. However, I intended this merely as an estimate in a back-of-envelope calculation, not a definitive value for expansion. A more realistic value may be more modest. Furthermore, I did the calculation along the lines of that of Eddington's (1926, pp. 371–372) computation of the average temperature of space due to starlight. Finally, I intended this expansion to refer mostly to extragalactic space, not necessarily to the distances of the nearest stars.

Lee also disagrees with my understanding of the 120-year limit of Genesis 6:3. It may be the majority opinion among those who believe in a global Flood that the 120 years refers to the time between when God revealed to Noah that He was sending the Flood until the Flood occurred. However, there are many Christians who think otherwise—that the 120 years refers to a shortening of man's lifetime (see, for instance, the *Zondervan NIV Study Bible*, pp. 13–14). A possible problem with the former interpretation is if Noah's age in Genesis 5:32 was his age when God revealed to him the coming Flood, then only 100 years transpired till the Flood came (Genesis 7:6). Fourteen verses after Genesis 6:3 (Gen 6:17), God said He was going to flood the world. I believe this is when longevity began to decline toward 120 years, with a later second decline leading to 70 years. With the Flood triggering the first episode of decline, it may have been in Peleg's time (whether creating several small language groups or splitting the continents) that longevity was sent further down to 70 years.

This interpretation is related to my understanding that in the immediate post-Flood but pre-Babel world, there was some division between the three sons of Noah. Lee disagrees with this. However, the division among three groups is strongly suggested by the way the table of nations in Genesis 10 is constructed, the similar geographical distribution of the descendants of each of Noah's sons, and the linguistic similarities between the various descendants of each of Noah's three sons.

Lee questioned my results of an age for the earth as 7500 years and the age of the universe as 8078 years. These merely were preliminary results based upon my proposed model. I could have just as easily worked them using the decay constant to derive the uniformitarian standard ages, instead of using the uniformitarian standard ages to derive the decay constant. It is noteworthy that these ages lie within 35% of 6000 years. The anomaly is presented for those who are experts in calculating the ages of the universe and of the earth.

Lee found slightly different results when he recomputed some of my cal-

culations. For instance, Lee got 1021.28 years, not 1023 years when he plugged 1056 into the equation. The discrepancy is due to round-off error and so is inconsequential.

Lee opined on my speculation about evaporation:

> If this were true, then obese people would regularly outlive skinny people. Furthermore, if body size were proportionate to life span, then blue whales ought to live for thousands of years, since they are many times more massive than we humans are. But that isn't the case.

This oversimplifies the situation, as there are other factors that affect longevity. These may be expressed as statistical variations. Like everyone, both skinny and obese people live within longevity's decay curve first or second standard deviations; but the key is not whether obese people do more often make it to the second standard deviation above longevity's curve; the key is to list possibilities for finding out what drove life spans incessantly down across generations. I have my doubts about skinny people, even world-renowned ones; e.g., Oppenheimer lived 62 years, von Neumann 53, both in the first standard deviation. Eli was big, fat and still a leader when he fell over, broke his neck, and died at 98, in the upper half of the first standard deviation. As for blue whales, they do live longer than humans, but not that much longer, maybe because they also live in heavy water, with its "serious health problems" (https://teaching.smp.uq.edu.au/fiveminutephysics/phys1171/L33_Radioactivity.html).

Lee further stated:

> The decrease in longevity is just as likely to have come from increased radiation affecting the earth, either from the weakened magnetic field, loss of the firmament, or other sources. Even if radiation were the cause, increased Carbon-14 production in the atmosphere, increased ingestion of Potassium-40 from post-Flood plants, and exposure to radioactive elements in the earth's crust seem as likely a cause as deuterium, perhaps more so considering that deuterium is not radioactive.

Lee is correct that deuterium is stable and does not decay, and he listed other appropriate examples of half-life concerns on health. Deuterium water, i.e., heavy water creates a non-half-life; i.e., nonradioactive health concern. See the website listed above.

Lee perceived an inconsistency in stating, "On page 167, Glatt says antediluvian life spans were ~950 years, but on page 168 he says ~900 years." However, page 168 addresses the average antediluvian life span, without Enoch, while on p. 167, I stated this is where you could start a curve, i.e., beginning with how long Noah lived, if you ignore possible beneficial antediluvian effects on longevity.

Lee claimed that my equation for the decrease in longevity is not the most correlated, stating that out of the seven equations he compared, mine ranked fourth. However, Lee presented no compelling reason to use any another correlation together with its equation. In his Table II, correlating between years versus generation mean different things, almost apples and oranges. Biologists correlated versus generation, to compare experimental effects on short-lived animals, e.g., fruit flies, to what might happen to humans; i.e., it's easier to watch over several generations of fruit flies. Notice his Sanford et al. citation analyzed versus generation; whereas in his book Sanford charted versus century. My graph versus time allowed comparison over time for various natural phenomena, including human longevity (Hubble Constant, half-life, age of the earth and universe.)

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Charles Glatt

Comments on Cratering and the Earth

I am writing in response to a recent article by W. R. Barnhart, where he claimed two surface features found in the American West "display the physics of shock and release waves produced by impacts" (Barnhart, 2017, p. 191). He discussed two examples in his paper, one from the Uncompahgre Plateau and the other from the so-called "TONCK" structure, centered in north Texas.

Lineaments are important structural features that often reveal regional trends in faults, joints, and/or folds in rocks. Barnhart is to be commended for using these types of data in his geologic studies. However, studies of lineaments must be ground-checked to determine their potential source. It appears that Barnhart did not fully delve into the available geologic literature for information about either of his claimed impact structures.

To his credit, Barnhart did utilize gravity data to try to justify his rather novel interpretation that these features represent impacts. Unfortunately, his paper, like others that focus primarily on surface features, is missing tangible subsurface data to back his interpretations.

The Uncompahgre Plateau is a basement-cored uplift that folded the overlying sediments along its flanks (Soreghan et al., 2015). Unaweep Canyon is near the northwest end of this uplifted region, where the plateau plunges downward toward the northwest. The gravity highs Barnhart shows in his Figure 5 (Barnhart, 2017, p. 196) are most likely reflective of Precambrian crystalline rocks near or at the surface, giving a greater gravity signature. The gravity lows he depicts reflect the adjacent flanks of the uplift that are composed of thick sediments, thereby lowering the rock density and the gravity signal. "Forcing" an impact template on to the northwest end of the plateau misrepresents the regional the geology of the Uncompahgre Plateau.

Barnhart's second example is the so-called "TONCK" structure, an acronym for the states it is claimed to include (Texas, Oklahoma, New Mexico, Colorado, and Kansas). This feature is supposedly defined by surface linears and also gravity maps. And yet again, it appears Barnhart "forced" an impact origin on this feature as well. The curvilinear lines he drew on his Figures 7–12 seem based more on a preconception than on actual empirical data. Removing the circles and curvilinear lines drawn on these images reveals little evidence supporting an impact. The "shock-release waves" shown on his Figures 10 and 11 are more likely outcrops of resistant units flanking anticlines and synclines (folds) that formed during the Laramide Orogeny (earliest Paleogene system). The structural trends he identified closely match the dominant directions of uplift and deformation observed across the Rocky Mountain region.

In addition, both of these areas have been drilled by numerous oil wells. The wells show only thick piles of sedimentary rock deposited during the Flood. I know of no wells in these regions that hit impact melt or cored through high-pressure minerals such as shocked quartz or found high levels of iridium (besides possibly at the K/Pg), often indicative of an impact.

As scientists, we cannot go "impact" hunting without having the subsurface and/or rock data to back our interpretations. Barnhart made a good start on his paper, but he lacked the finish. He should have ground-checked his interpretation with the available subsurface data.

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More on Cratering

The note from the editor on W.R. Barnhart's (2017) article on earth cratering based on lineaments indicates that the article will be controversial. Indeed, that is true. Although there are less than 200 confirmed Earth impacts, the Flood would have destroyed much of the evidence of many more, leaving only remnants at best. The Flood's violence would have obliterated evidence especially of the earliest impacts. Clarey (2017) has shown that even one of the most substantiated impacts, the Chicxulub impact on the Yucatan coast, has many equivocal features. Barnhart is attempting to gather criteria that point to impacts. However, I believe his indicators are inadequate for determining whether a site is a meteorite impact.

Based on lineations or segments of lineations called linears, Barnhart claims to make a case for two large impacts: (1) one centered over the northern Uncompahgre Plateau, southwest Colorado, and (2) one centered over northwest Texas with a diameter of about 869 km. I will focus on the claimed impact centered over the northern Uncompahgre Plateau, the area with which I am most familiar.

It is difficult to make out the details of Barnhart's claimed impacts because the figures are difficult to interpret. Barnhart relies on arc-shaped lineaments to define his impacts. Criteria considered certain of an impact, such as shocked quartz or shatter cones (French and Koeberl, 2010), are not used, but these ephemeral impact criteria could have easily been destroyed during the Flood. So, Barnhart essentially relies on the arc shape of topographic and geophysical features. It is well known that there are many other geological processes, other than impacts, that can cause arc-shaped or circular features, such as volcanic calderas or maars (Stewart, 2003). However, these all occur at the small scale, less than about 50 km in diameter, and the cause of the features can usually be determined. So, Barnhart is correct to focus on arc-shape features, but there may be other large-scale geological processes that can produce these features.

Lineaments are rarely mentioned in geology. A lineament is defined as "an extensive linear topographic feature which may reflect the trend of some underlying structure, often detectable only from aerial photography" (Smith, 1981, p. 473). As Barnhart points out, there is subjectivity in determining a lineament (Barnhart, 2017, p. 193). Well-defined lineaments would be faults or shear zones, such as fracture zones in the oceans. On the continents, a lineament may be a linear fault valley. Whether one can connect linears and lineaments to form an arc or circular pattern over the large scale is questionable and requires much more research.

Barnhart proposes that the intersection of the compressive and rarefaction (release) pulses in an impact shock wave with the earth's surface will produce concentric ridges and troughs. This he calls the "law of the wall" mechanism that produced circular lineaments on the surface. This is speculative and needs much more verification. Barnhart suggests that this law of the wall will even produce mountains and valleys (Barnhart, 2017, p. 195).

Barnhart suggests an impact over the extreme northwestern Uncompahgre Plateau produced circular lineaments of which Unaweep Canyon (Figure 1) is one of the valleys formed by the rarefaction pulse of the shock wave (Barnhart, 2017, p. 196). A corresponding rarefaction pulse created the wide Grand Valley north of the postulated center. Barnhart correctly states that Unaweep Canyon runs perpendicular to the northwest-southeast trend of the Uncompahgre Plateau and is not associated with faults or rivers (p. 196). Based on the canyon fill to about 325 m, he then states that the canyon was carved between the deposition of the "Permian" Cutler and the "Triassic" Chinle Formations, about 250 million years ago within the uniformitarian timescale. He then traces arc-shaped linears (his Figure 7) on the edge of the circle formed by

Figure 1. Unaweep Canyon.

Grand Valley and Unaweep Canyon, based on "topographic variations in the Chinle Formation" that would have formed at the same time as the formation as Unaweep Canyon. The procedure for drawing the arcs is questionable, not only because the Chinle Formation likely is irrelevant (see below), but also because there are not enough data points to draw arcs. The procedure is subjective and speculative.

Using outcrops of the Chinle Formation on the Uncompahgre Plateau is questionable because it is unlikely that the canyon was cut between the deposition of the Cutler and the Chinle Formations. Based on "dates" from a borehole, Soreghan et al. (2007, 2009) postulated that the canyon formed during the late Paleozoic "ice age" (note that Unaweep Canyon is U-shaped), filled with debris, and was exhumed in the Cenozoic. But this idea is controversial (Hood, 2009), and newer uniformitarian ideas postulate that the canyon was cut by the "ancestral Gunnison River" in the late Cenozoic, from about 11-1 million years, up until the Gunnison River was captured by the Colorado River between 1.4 and 0.8 million years (Aslan et al., 2014). However, rocks from the "ancestral Colorado River" were found west of the pass (Hood et al., 2014).

Unaweep Canyon is enigmatic to uniformitarian geologists, but it can be explained as a wind gap in which a channelized Flood current flowing southwest cut the canyon on the northern end of the Uncompahgre Mountains (Oard, 2013). With time and for some reason, probably due to tectonics, the Flood current cutting Unaweep Canyon quit. The water then was redirected down the Grand Valley, leaving Unaweep Canyon as a wind gap. Northeast of Unaweep Canyon is the valley of the Colorado River. This explains how rocks from that valley were deposited in Unaweep Canyon. It is evidence for the Unaweep Canyon having been carved by a Flood current moving northeast to southwest.

Figure 2. Large rocks deposited in Unaweep Canyon.

I found large, water-deposited, rounded to subrounded boulders over 1.5 meters in long dimension on the west side of the pass. This would be a depositional area during the erosion of Unaweep Canyon (Figure 2).

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Michael J. Oard

Response to Oard's and Clarey's Letters to the Editor

I was pleased that Mr. Oard and Dr. Clarey took the time to consider my claims that impacts can be recognized in geomorphology by circular lineaments. While Clarey is more familiar with gravity mapping, Oard found some figures hard to interpret, and I have to agree. New areas of investigation require a new vocabulary of evidence.

Oard's hope is that there "may be other large-scale processes" that we don't presently recognize found to produce circular lineaments. "Island arcs" are such a feature. Found in many oceans and continents, they are believed to be building blocks of plate tectonics swept up in the continents. While the explanation may be wrong, it is a tacit recognition that arcuate lineaments are recognize all over the globe.

"Lineaments are rarely mentioned in geology" is a subjective statement. Table 1 (Barnhart, 2017, p. 192) named a few historic individuals who contributed to the discussion, but the list could be expanded many times over in recent publication. Continuing in my "Cratering and the Earth" series, "Seeing Lineaments in the Pacific Ocean" (Barnhart, a) and "Seeing lineaments in Northern California" (Barnhart, b), will lead the reader in much greater recognition and exploration of linears. It is not a matter of how much lineaments are talked about but how much readers can see for themselves. Barnhart (a) shows large mountain ranges and adjoining parallel valleys, not unlike the Uncompahgre Plateau and Unaweep Valley, recurring across the Pacific Ocean Basin. The reoccurring linears around the Unaweep circle is an extension of the ideas in Barnhart (b). The occurrence of concentric linears is the key to geomorphology expression of shock-release wave pairs originating at a point, the impact point. Oard says my drawing of the circular lineament I used to indicate the Unaweep impact is subjective and speculative. I note that Clarey did not have the problem seeing the circular lineaments but rather questioned my interpretation.

"It is unlikely that the canyon was cut between the deposition of the Cutler and the Chinle Formation," Oard says—a fine assertion, but where is your evidence to support it? Soreghan et al (2015, p. 320) asserts, erosional waters "exhumed a paleovalley … filled with Permian strata" (the Cutler is early Permian, and Chinle is late Triassic). Cutting the canyon in the Cenozoic would not fulfill their "exhuming in the Permian" evidence. I find that a U-shaped valley is just what my model would predict for a release-wave valley consistent with my Figure 3 (Barnhart, 2017, p. 195).

Oard explains Unaweep Canyon as a wind gap. The idea of wind and water gaps are fairly simple and logical, and he has used it for several years. I challenge that these gaps formed randomly (Barnhart, b). Instead, I am emphasizing the water preferring some path and abandoning others in linear patterns consistent with impact lineaments. Oard cites "time" and "tectonics" as a cause, but tectonics, for all its popular support, is challenged by lineaments across the Pacific and through island arc of Northern Cailfornia (Barnhart, a, b), which says that plate tectonics could not have happened and impacts were the primary determiner where water flowed and eroded. The Unaweep was eroded by a flow of water in a path determined by the pattern the impact produced. Additionally, we are dealing with a Flood of only a bit over a year's duration; where does "time," as it is commonly used in geologic processes vocabulary, fit in any Flood model?

One of the problems with researching in an area that is less known and is in opposition to the accepted paradigm is that there is a steep learning curve to climb and the reader doesn't know if the climb is worth it. In presenting a new model, I would ask to be judged on a *preponderance of the evidence* to support this model over other competing models after a significant hearing. Regrettably, the first article primarily dealt with learning to see the evidence, rather than a defense of it. As yet, the reader does not have a significant part of the evidence, and with a lack of evidence the tendency is to fall back on many assumptions. "The Flood would have destroyed much of the evidence of many more [impacts], leaving only remnants at best." "The Flood's violence would have obliterated evidence especially of the earliest impacts" The Uncompahgre Plateau "formed during the Laramide Orogeny." These are three often-repeated assumptions, which I will dispel with further articles. I will show that the Unaweep and TONCK impact structures do not stand isolated but are each one in a series involving overlapping patterns of many larger and smaller impacts covering all the earth's surface.

Clarey states, "The 'shock-release waves'... are more likely outcrops of resistant units flanking anticlines and synclines (folds) that formed during the Laramide Orogeny … the dominant directions of uplift and deformation observed across the Rocky Mountain region." I agree the shock-release waves produced outcropping of resistant units, but what we disagree on is the mechanism. The "Laramide Orogeny" is the accepted "just-so" story of plate tectonics, but it is just an assumption. Many name it, but few admit the stumbling block it is. Plate tectonics is modeled to produce mountains at plate boundaries, not mid-plate as the Laramide Orogeny model requires.

I agree that the Unaweep's origin is "enigmatic," which is why I was excited when I recognized circular lineaments that are involved it. Both letters want me to defend that the circular lineament for

the Unaweep and TONCK structures are impact in origin. I could do so, to the extent of many thousands of words. I could talk extensively of the role the Uncompahgre, Rocky Mountain, Gulf of Mexico, and Llano impacts had in forming the basement, and the New Zealand, Penrhyn, and Amazon impacts had in producing the "Laramide orogeny" results. I will as this series continues.

While Clarey recognized that I did not speak of "impact melt or … high-pressure minerals," he should not assume I did not consider them. The Minthorn, Southern California; Paris Mountain, South Carolina; Tver, Russia; and Gulf of Mexico, U.S. show a considerably diverse expression of impact melt, seemingly connected to the impact size, with the largest lying below the MOHO, imaged on density scans, and the smallest visible in road cuts. These are some of the topics for future papers. (I would gladly discuss this developing field with anyone who wishes to email me their thoughts and questions.)

These are my just-so stories, and I will get to them as the reader gains a greater understanding of my evidence. It would not do much good to tell you how impacts formed the Grand Canyon until you can see what I believe is the evidence in simple lineaments.

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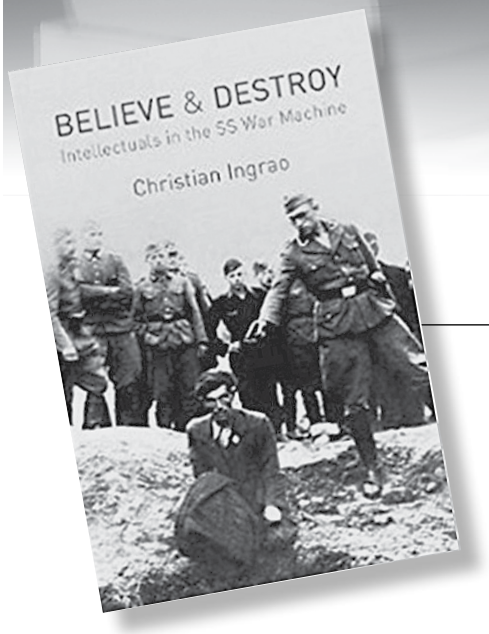
Media Reviews



Believe and Destroy: Intellectuals in the SS War Machine

by Christian Ingrao

Translated by Andrew Brown. Polity Press, Malden, MA, 2013, 432 pages, $30.00

This major academic study convincingly documents the critical role of Germany's "best and brightest" in the prosecution of the Nazi genocide. Author Ingrao, a leading Third Reich historian, uses mostly primary sources (including letters, interviews, and the résumé of former SS officers who were university educated, many of whom were academics). The goal is to understand the mindset that turned scholars into mass murderers and to determine why so many Germans with good scientific backgrounds willingly engaged in the mass murder of millions of innocent men, women, and children. The fact is that along with ordinary soldiers, leading SS officers, who represented the best of German education, participated in the most heinous crimes in modern history.

The study researches 80 individuals, focusing on their academic accomplishments, networks of their friends, and university activities. The intellectuals in the study were all children during the First World War. Ingrao argues that this experience created an insecurity and paranoia about the possible destruction

of the Aryan race that they carried into adulthood. These fears were then used by the Nazi movement to manipulate many to commit genocide.

Also discussed is how and why these talented individuals joined the SS and/or the Nazi party. The original Nazi goal was to relocate those persons they had labeled inferior races (including Jews, Gypsies, Russians, and Poles among others). Instead of relocation, the Nazis then resorted to genocide to accelerate the elimination of these inferior races.

One book section focuses on how the SS intellectuals dealt with the use of violence in carrying out their Darwinian eugenic goals. Ingrao also discusses how they rationalized their behavior when placed on trial after the war. While on the witness stand, the obviously very bright individuals offered a variety of justifications for the racial purging violence.

Ingrao documents Nazi atrocities and explores the roots of Nazi behavior, particularly that of the graduates of leading German universities. His work documents that these often-unfeeling killers were programmed with a strong sense of discipline that held the superior-race concept and the fatherland with an almost religious zeal.

While they murdered millions of people during and before WW2, the Nazis, had a much larger goal in mind, namely to murder and/or enslave most of the non-Aryan peoples of Central Europe in order to create lebensraum (living space) for the superior Aryan race. To achieve this, they planned to create large farms and other enterprises worked by non-Aryan slaves. The long-term goal was to eventually murder all the members of the putative inferior races.

Nazi supporters believed that they were creating a better world through their sacrifice. One man, a high school teacher before he became a soldier, wrote to his mother from the battlefield about the death of a family member who "has now become one of those who have helped to build the future of a greater Germany, with all the blood and all the strength of his heart" (pp. 6–7). He added that the family member died giving his last full measure of devotion to the cause of a better world void of inferior races.

Young men and women who went east to help relocate the Volksdeutsche saw their efforts, not as genocide, but as a labor on behalf of Germany's glorious future. One young man, trained as an anthropologist, wrote a report that expressed in glowing terms the belief that "anyone who has taken part in an Umsiedlung [resettlement] will remember those tough but wonderful times with nostalgia" (p. 133). He added that the "war has powerfully shown us that our lives had a completely different meaning from that of simply unfolding along the normal paths of middle-class family life" (p. 7). These men

> are a part of a great and sacred aim … leading us on towards something great and eternal … and we are the chosen ones, the chosen tools. Should we really, truly be happy at this? Around me everything is verdant and blossoming, and the birds are exuberant and joyful in the light. How much more grand and beautiful will be the spring that follows the Great War! (p. 7).

It was genuinely believed that the intellectual and scientific underpinnings of Nazi ideology, which we today call "pseudo-science," was supported by science. Along with science was mysticism, which endorsed the Nordic racial doctrine with both an explanation for the 1918 defeat and a means of redemption.

Ingrao's book is a chilling read, not only because of his descriptions of the many Nazi atrocities, but also because of his documentation of the Darwinian racist justifications and rationalizations that made them possible. Like educated extremists today, they interpret the world in racial (and racist) terms (p. 62). For these men, Nazism was not an isolated phenomenon but rather an ideology, as Darwinian eugenics, that can easily be used to justify the necessity of killing for a cause.

Men did not become Nazis. Rather, the ideology they brought with them to the Nazi Party *became* the Nazi ideology. They were often college student activists championing the cause of ethnic German communities, proponents of an existing radical worldview learned at college. Their activism, their adherence to "raciology," and their nationalistic attitudes made them very attractive to the Nazi Party.

In short, the dark side of human nature and Darwinism is thoroughly explored in the book's impeccable research and detached analysis. It is a valuable addition to the extensive existing literature on Darwinian eugenics and the Third Reich. Christian Ingrao's *Believe & Destroy* is a masterful investigation into the Nazi ideology, beliefs, and worldview that motivated the well-educated intellectuals serving in the SS.

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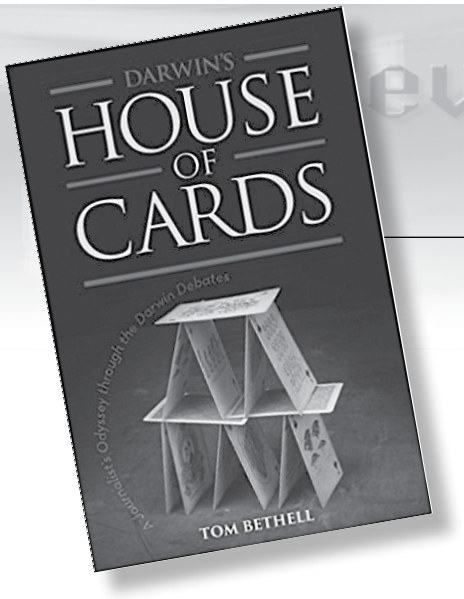

Darwin's House of Cards

by Tom Bethell

Discovery Institute Press, Seattle, WA, 2017, 293 pages, $21.95

Tom Bethell is an experienced journalist who has served as Washington editor for *Harpers* and a contributing editor to *Washington Monthly* and *The American Spectator*. His book is part of the effort by the *Discovery Institute* think tank to present the case for intelligent design (ID) from an information science perspective. Hence references to Genesis and biblical arguments for ID are scattered throughout the book but not discussed in detail. The theme is that today, 158 years after Darwin, the theory of evolution more closely resembles a "house of cards" built out of flimsy icons rather than hard evidence. This theme is amplified throughout the book.

The book begins with the title of Darwin's famous book: *On the Origin of Species by Means of Natural Selection, or the preservation of favored races in the struggle for life*. Rarely does the full title of this book appear, as today it sounds embarrassingly racist. Bethell acknowledges (p. 12) that "medieval Christianity actually laid the groundwork for the blossoming of science." Bethell also points out that natural selection (NS) is a circular argument and that evolutionists view NS as an active agent with a goal of a thriving population of the more fit. Bethell obtained his material by interviewing many of the lead evolutionists and philosophers of science, including Karl Popper. Bethell states (p. 45), "It is time to out that Darwinian evolution never did a have much in the way of evidence to support it…it is often embraced more for the support that it gives to atheistic philosophy than for its science…but as new discoveries have been made since 1959, the reasons for accepting the theory have diminished rather than increased."

Chapter 4 covers common descent, and chapter 5 is entitled "Natural Selection: A Closer Look." A discussion of species extinction, homology, convergent evolution, the fossil record, and evolution in public museums occupy the middle of the book. The last half of the book then deals with the logical consequences of evolutionary theory. Chapter 13 is on "Intelligent Design and Information Theory" and chapter 14, "Darwin and the Philosophy of Materialism," discusses methodological naturalism. The emptiness of materialism with respect to free will, life after death, and matters of the mind is artfully pointed out by Bethell. DNA is given one chapter (15) with discussions of junk DNA and the human genome project, and theistic evolutionists such as Ken Miller. Chapter 16 is helpful to creationists with its discussion of Lenski's evolving bacteria, which is not found by Bethell to be the evolution evidence Lenski claims.

The latter part of the book concerns sociological and philosophical aspects of evolutionary theory. The last chapter is entitled "The Rise and Fall of Progress." Progress and optimism came with libertarian Herbert Spenser and was dominant in social science between 1880 and 1920. The communist era in Russia, China, and other countries followed on a foundation laid by Darwin that central control of the government would lead to universal prosperity. Under communism, all the people of the world would prosper. After the fall of the Berlin Wall in 1989, communism was no longer "the answer." But what would replace this ideology of communism?

Although evolution is consistent with communism, as it was also with the Nazi idea of the Aryan race being more evolved (part of Darwin's "favored races"), the wind has come out of the sails of optimism. Humans have a never-ending longing for purpose and meaning in life.

On reading this book, I realized that evolution is a religious faith in materialism alone with many "denominations" having different practices and emphases. About 100 years ago, the salvation of man was through eugenics, promoting the birth rates of the "fit" over the "unfit" part of humanity. Now, population control through abortion and devaluation of marriage is the faith in action of environmentalists and climate-change advocates. Humans are religious by nature, and Bethell's book makes this clear in the story of Darwin's influence on our history. Bethell is a philosopher who covers the history of Western civilization since Darwin came on the scene. Philosopher Bethell challenges natural selection and the power of mutations to innovate. Bethell does not, however, note the evidence for a young earth in any part of the book. Those looking for a good review of the negative legacy Darwinism and neo-Darwinism will enjoy the book.

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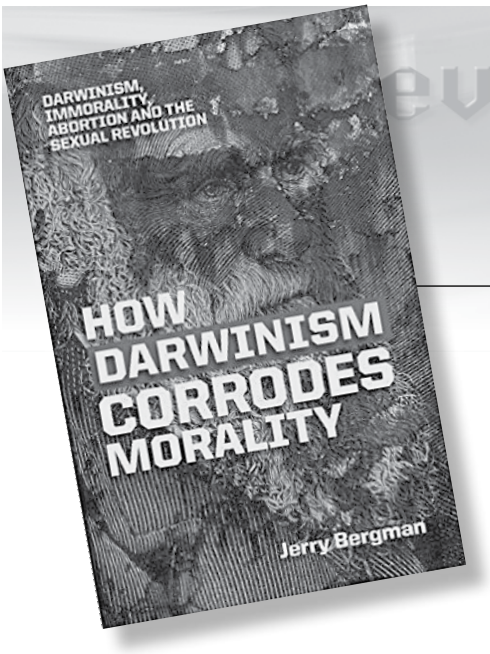

How Darwinism Corrodes Morality

by Jerry Bergman

Joshua Press, Seattle, 2017, 312 pages, $18.00

Jerry Bergman, author of 40 books and counting, details the negative influence of Darwinism on a civil society. As Bergman explains, the purpose of this book is not disproving the theory of evolution but rather highlighting how evolutionism through intellectual elites has degraded the moral standards of the Ten Commandments.

The initial chapter, "Darwin and Morality," discusses influential people, including Havelock Ellis, Alfred Kinsey, and Margaret Sanger. Sanger was particularly determined to present euthanasia as the way to improve humanity. The theory of evolution devalues human life in that some lives are inherently superior to other lives. This follows from the Darwinian notion of survival of the fittest. Chapter 5 concerns how evolution justifies abortion and clearly establishes Bergman's thesis. Sigmund Freud (about whom we don't hear much anymore) based his psychoanalysis on the assumption of evolution. Freud and Karl Marx favored their solutions to the human problem because they were atheists who did not believe sin was a reality. The solutions were to manipulate humanity—Marx through government solutions for the masses and Freud on a person-to-psychiatrist basis.

Friedrich Nietzsche (1844–1900), son of a Lutheran pastor in Germany, had an enormous influence on the intellectuals of Germany adopting the racist views of Nazism. Nietzsche was vehemently opposed to mixing superior Germans (Aryans) with "inferior" races (Poles, blacks, Jews, and other non-Aryans). One reason Hitler started World War II was to subjugate and even eliminate the inferior races. Darwin himself did not advocate euthanasia and wars on the less fit; however, his influence gave momentum and reasons (excuses) to make war on people branded as inferior.

In chapter 8, Bergman presents the gruesome tales of Norwegian Anders Breivik and the American Charles Manson, both devout evolutionists. Breivik took the lives of 77 persons in a killing rage. Charles Manson admired Nietzsche and hated Christianity. He was tried for killing 7 people with his "family" and trumpeted racial supremacy of whites over other races. Chapter 9 concerns Benjamin Spock (1903–1998), the "baby doctor" who was highly respected in the US during his years of influence. At some point Spock realized that a moral code (law) was needed for a just and fair society. Spock is said to have realized later in life the harm and moral corrosion that emerges from atheistic Darwinism.

Chapter 10 addresses the religious fervor in academia about evolution. The Judeo-Christian basis for morality in the United States has come under assault, mostly in the universities. In fact, today a slight majority of adult Americans accept either theistic and/or atheistic evolution. We are constantly told that only anti-science fundamental Christians espouse creationism. But Americans, as all humans, are religious at the core, needing faith in something if not in Christianity. Prestigious universities such as Harvard and Yale have substituted environmentalism in the place of Christianity (ironically, schools founded to educate pastors for the Protestant ministry). Teaching about the Christian faith in these two institutions is mostly by non-believers in orthodox Christianity. Conversely, those teaching about Hinduism, Buddhism, and Islam are often devout believers in these religions.

Chapter 11 takes note of the Christian church in the US and Europe (mostly Sweden and Germany) and the eugenics movement. Denominations that reject evolution on biblical grounds also tend not to promote or justify eugenics. Bergman gives examples and geographical locations in the US that sanctify birth control through eugenics, including the Unitarian, Methodist, Congregational, Episcopal, and Presbyterian liberal wings. The *Catholic Encyclopedia* of 1913 stated opposition to both evolution and eugenics, while liberal Catholics gave support to the eugenic movement. Reformed Jewish rabbis enthusiastically support evolution and eugenics. Bergman states that "nowhere did the churches cave in to eugenics more fully than in Nazi Germany" (p. 219). Eugenics arises quite naturally from an evolutionary worldview, and one early promoter was Francis Galton (1822–1911), a second cousin of Darwin. "Eugenics" here means an active governmental action in Germany and other European nations (and sadly in

the USA) to stop, through persuasion and even sterilization, the births of those deemed inferior.

The Nazi movement and eugenics are traced in chapter 12. A similar but less drastic movement in carrying out eugenics programs occurred in Britain through writer Karl Pearson, who admired what was going on in Germany. Japan is generally not noted for Darwinian views, but Bergman (chapter 16) documents that Emperor Hirohito (1901–1989) was well versed in Darwinism and promoted the Japanese as being superior to its Asian and Western enemies in the 1940s.

Bergman's book connects the dots and the roles of individuals, dictators, professors, writers, and even "Christian" leaders in paving the way for the moral corrosion that is consistent with a mature Darwinian view of the natural world. Those wanting a clear historical tracing of the atheistic and corroding influence of Darwinism should read this book.

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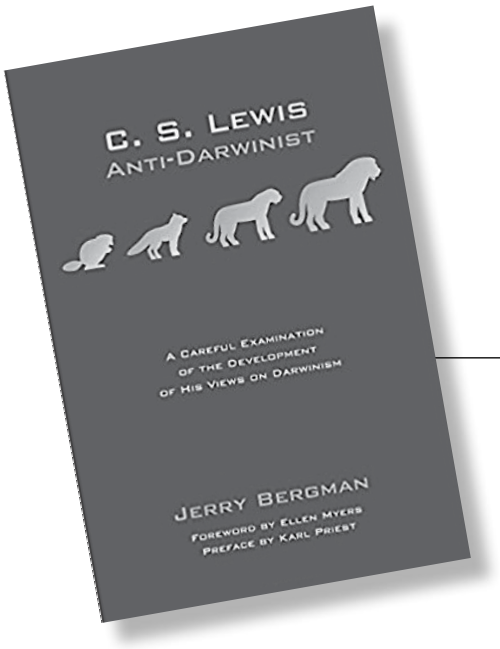

C. S. Lewis Anti-Darwinist: A Careful Examination of the Development of His Views on Darwinism

by Jerry Bergman

Wipf & Stock, Eugene, OR, 2016, 146 pages, $21 paperback, $42 hardcover

Author Bergman has sorted and culled from various sources to create a mosaic spanning decades of C. S. Lewis's views about evolution. According to Bergman, Lewis became increasingly antagonistic toward evolution as he matured in years, but this was also mixed with Lewis's reluctance to reveal his thinking publicly about the topic. He wanted to win atheist-types to Christ, knew he was not a biological authority, and did not want skeptics to be able to use his nontraining in biology as an excuse not to listen to him in areas of his expertise. Lewis had been a professed atheist himself, but even prior to his conversion to Christianity he had reservations about evolution. This reservation grew significantly after he became a Christian, believing it to be "the central and radical lie in the whole web of falsehood that now governs modern civilization" (p. XV).

Lewis was aware of how subtly evolution has permeated society, even in advertisements. When someone says this is the "latest" product, it is meant to imply that it represents an improvement (p. 86), but how can we be sure that something that is the "latest" is better than what was before?

Lewis also objected to the depersonalization of evolutionary science. How can evolution produce trust and tenderness between persons (cf. his comments about a child's trust in the mother; p. 92)? In "The Funeral of a Great Myth" essay readily available online, Lewis writes about D. M. S. Watson, professor of zoology at University College, London, from 1921 to 1951, who said, "Evolution is accepted by zoologists not because it has been observed to occur or ... can be proved by logically coherent evidence to be true, but because the only alternative, special creation, is clearly incredible" (pp. 89, 114).

Further, the Lewis essay first disproves evolution since reason cannot evolve from nonreason: "To reach the positions held by real scientists, which are taken over by the Myth, you must, in fact, treat reason as an absolute. But at the same time the Myth asks me to believe that reason is simply the unforeseen and unintended by-product of a mindless process at one stage of its endless and aimless becoming. The content of the Myth thus knocks from under me the only ground on which I could possibly believe the Myth to be true. If my own mind is a product of the irrational—if what seem my clearest reasonings are only the way in which a creature conditioned as I am is bound to feel—how shall I trust my mind when it tells me about Evolution?"

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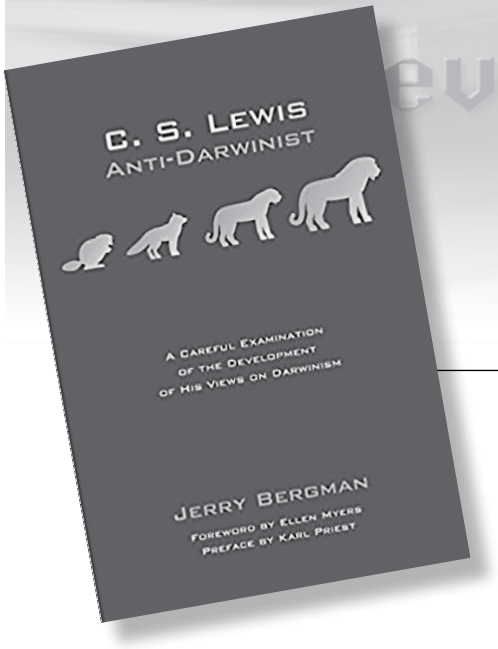

C. S. Lewis Anti-Darwinist: A Careful Examination of the Development of His Views on Darwinism

by Jerry Bergman

Wipf & Stock, Eugene, OR, 2016, 146 pages, $21 paperback, $42 hardcover

C. S. Lewis called himself an atheist at age 15 because of "science." After much soul-searching and hungering for truth, Lewis became a Christian at age 33 with the help of apologetics books by George MacDonald. C. S. Lewis followed in MacDonald's footsteps, and he too eventually became a well-known Christian apologist. Some critics have charged that Lewis was a theistic evolutionist throughout his life. A case can be made for this from several of Lewis's ambiguous statements in his books, especially if the statements are taken out of context.

Author Bergman shows in this well-documented book that Lewis had significant doubts about Darwinism soon after he became a Christian. His concerns deepened as he learned more about Darwinism. Lewis was reluctant to challenge evolution in print because he was not a scientist. Because of this, his attitude toward evolution is best gleaned from private letters, and it is these letters that Bergman analyzes.

Lewis writes that he was greatly impressed by the wonders of nature, which reinforced his belief in the Creator. He would probably be classified today more as a member of the intelligent design movement. Lewis wrote that he was especially concerned about the moral ramifications of evolution, including eugenics.

Lewis did challenge evolution in print late in life when he published the book, *They Asked for a Paper*, in 1962. After his death in 1963, Walter Hooper published Lewis's anti-evolution essay, "The Funeral of a Great Myth," in the book *Christian Reflections*. He also published a mocking anti-evolution poem written by Lewis in 1957 under a pseudonym and titled "The Evolutionary Hymn."

Lewis had some perceptive observations about the subject of evolution. He noted that the strong believers in evolution, when challenged, acted affronted, as though their religion was being attacked. He observed that most people accept evolution on faith mainly because they do not want to believe in God or else because they trust some authority figure who said it was true.

I recommend this book to those who have been confused on whether Lewis was a theistic evolutionist or not and to learn of his true attitude toward evolution.

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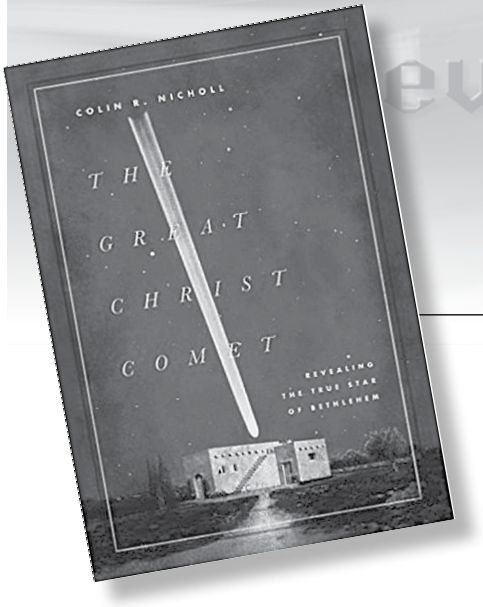

The Great Christ Comet

by Colin Nicholl

Crossway Books, Wheaton, IL, 2015, 368 pages, $40.00

This book is a comprehensive effort to describe and identify the Christmas Star. Author Nicholl earned a PhD in theology from the University of Cambridge. A former professor of New Testament at Gordon-Cornwell Seminary, Massachusetts, Nicholl currently devotes his time to biblical research.

The book received a major boost during a lengthy interview with Eric Metaxas on his program *Socrates in the City*. Some of the accolades given to the book appear to be a bit over the top. Metaxas writes, "I am simply in awe of this book, an absolutely astonishing triumph." J. P. Moreland echoes this, saying, "A stunning book. It is now the definitive treatment of the subject" (back cover). These words are all the more surprising since the comet view of the Christmas star has been around for 1800 years, going back to Origen Adamantius (p. 126).

There certainly is no lack of interest in the Star of Bethlehem. A lengthy article appears in the *Bible and Spade* periodical (Culley, 2016). A detailed study, Werner Gitt's paperback *What Was the Star of Bethlehem* is now translated into English by Carl Wieland (2016). Danny Faulkner's *The Created Cosmos* has a chapter on identification of the star (2016). My own question-answer astronomy book also covers the Christmas Star topic (DeYoung, 2010).

In 368 pages, author Nicholl gives an analysis of both Scripture and various suggestions as to origin of the Christmas Star. A supernova or conjunction of planets are both considered and found wanting, and rightly so. However, I was disappointed that little time is spent on the option of a supernatural guiding light. Just two objections are offered: First, translating Matthew 2:2 as "We saw his star rising," Nicholl sees this as "misleading if an astronomical phenomenon is not in view" (p. 85). This objection, of course, depends on the translation. As a second objection to the supernatural view of the star, the author asks how the Magi would have known that "someone had been born, that he was King of the Jews, and that he was worthy of worship?" (p. 85). One might suggest that the Magi were told these things by God, as also occurs in Matthew 2:12. In addition, since the Magi probably came from Babylon, they may have had written records available dating from the biblical Daniel five centuries earlier. The supernatural view of the Christmas Star remains a credible view that has stood the test of time and all competing ideas.

The book title reveals Nicholl's conclusion that the Magi were influenced by a comet. And not just any comet but a long-period variety that acted in a special way to lead the Magi to Jerusalem, and later with its tail lined up directly above the house in Bethlehem where the Lord was (Matthew 2:9).

In spite of strong endorsements by many writers, there are several challenges to the comet view of the Lord's Star. (1) Why is there no extrabiblical record of this comet? There are no comets recorded in the skies at the time of the Lord's birth, 5–6 BC. The author rightly states that not all historical comets were recorded. However, this particular comet is claimed to have been spectacular, the brightest comet ever; hence the book title. Meanwhile, other contemporary comets were indeed recorded, including Comet Halley in 12 BC and also the 5 BC comet hui-hsing commemorated by early Chinese astronomers. In suggesting the path of the imagined comet, several elements are listed, including its eccentricity, inclination, and perihelion date, but all are entirely speculative. (2) When the Magi reached Jerusalem, why were Herod and his scholars not familiar with this comet? In fact, Matthew 2 suggests that the Magi were the only people who had observed the special light. A major comet in the sky surely would have been popular news in Jerusalem. (3) As an additional question, how could the comet stop and point to a particular house in Bethlehem? The direction a comet tail points depends entirely on the observer's location. For example, just try to reach the end of a rainbow! (4) As a final challenge to the comet idea, such appearances have historically been associated with negative events in history,

not the birth of the King of the Jewish nation. Author Nicholl does mention some positive historic events associated with comets, but these are exceptions to the general rule.

To bolster the comet identification of the Christmas Star, the author suggests that many additional "star" references in Scripture are actually comets. He includes Genesis 1:14, Numbers 24:17–19, Isaiah 9:2, Revelation 12:1–2, and others. Frankly, it is a stretch to claim all these biblical star references are actually comets. The author's speculation becomes extreme in tying in the Christmas comet with the constellation Virgo, the Virgin. It is suggested that the comet passed through this group of stars, with the glowing comet coma resembling the infant Christ within the womb of the Virgin. Then the comet later emerging from her body mirrors the actual birth of the Lord Jesus from His mother Mary. How does one begin to evaluate this "Gospel in the Stars" story?

At one point in the book it is suggested that there is actual historic evidence for the Christmas comet after all. Since the Magi probably came from Babylon, "then, in Matthew 2 we have indirect Babylonian records of the Christ Comet" (p. 148). Is this not circular reasoning, assuming the Star of Bethlehem is a comet and then using this assumption as comet evidence?

Personally I do not see in this book a refutation of the Christmas Star being a temporary, supernatural light that guided the Magi to the Messiah. The first Christmas was a time of miracles, and this may well include the guiding star. Regardless, Colin has given us a comprehensive guide to comets and Christmas Star theories. The book provides a 5-page glossary and 20 pages of bibliography.

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Instructions to Authors

Submission

Electronic submissions of all manuscripts and graphics are preferred and should be sent to the editor of the *Creation Research Society Quarterly* in Word, WordPerfect, or Star-Office/Open Office (see the inside front cover for address). Printed copies also are accepted. If submitting a printed copy, an original plus two copies of each manuscript should be sent to the editor. The manuscript and copies will not be returned to authors unless a stamped, self-addressed envelope accompanies submission. If submitting a manuscript electronically, a printed copy is not necessary unless specifically requested by the *Quarterly* editor. Manuscripts containing more than 35 pages (double-spaced and including references, tables, and figure legends) are discouraged. An author who determines that the topic cannot be adequately covered within this number of pages is encouraged to submit separate papers that can be serialized.

All submitted manuscripts will be reviewed by two or more technical referees. However, each section editor of the *Quarterly* has final authority regarding the acceptance of a manuscript for publication. While some manuscripts may be accepted with little or no modification, typically editors will seek specific revisions of the manuscript before acceptance. Authors will then be asked to submit revisions based upon comments made by the referees. In these instances, authors are encouraged to submit a detailed letter explaining changes made in the revision, and, if necessary, give reasons for not incorporating specific changes suggested by the editor or reviewer. If an author believes the rejection of a manuscript was not justified, an appeal may be made to the *Quarterly* editor (details of appeal process at the Society's web site, www.creationresearch.org).

Authors who are unsure of proper English usage should have their manuscripts checked by someone proficient in the English language. Also, authors should endeavor to make certain the manuscript (particularly the references) conforms to the style and format of the *Quarterly*. Manuscripts may be rejected on the basis of poor English or lack of conformity to the proper format.

The *Quarterly* is a journal of original writings, and only under unusual circumstances will previously published material be reprinted. Questions regarding this should be submitted to the Editor (CRSQeditor@creationresearch.org) prior to submitting any previously published material. In addition, manuscripts submitted to the *Quarterly* should not be concurrently submitted to another journal. Violation of this will result in immediate rejection of the submitted manuscript. Also, if an author uses copyrighted photographs or other material, a release from the copyright holder should be submitted.

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Submitted manuscripts should have the following organizational format:

1. Title page. This page should contain the title of the manuscript, the author's name, and all relevant contact information (including mailing address, telephone number, fax number, and e-mail address). If the manuscript is submitted by multiple authors, one author should serve as the corresponding author, and this should be noted on the title page.

2. Abstract page. This is page 1 of the manuscript, and should contain the article title at the top, followed by the abstract for the article. Abstracts should be between 100 and 250 words in length and present an overview of the material discussed in the article, including all major conclusions. Use of abbreviations and references in the abstract should be avoided. This page should also contain at least five key words appropriate for identifying this article via a computer search.

3. Introduction. The introduction should provide sufficient background information to allow the reader to understand the relevance and significance of the article for creation science.

4. Body of the text. Two types of headings are typically used by the *CRSQ*. A major heading consists of a large font bold print that is centered in column, and is used for each major change of focus or topic. A minor heading consists of a regular font bold print that is flush to the left margin, and is used following a major heading and helps to organize points within each major topic. Do not split words with hyphens, or use all capital letters for any words. Also, do not use bold type, except for headings (italics can be occasionally used to draw distinction to specific words). Italics should not be used for foreign words in common usage, e.g., "et al.", "ibid.", "ca." and "ad infinitum." Previously published literature should be cited using the author's last name(s) and the year of publication (ex. Smith, 2003; Smith and Jones, 2003). If the citation has more than two authors, only the first author's name should appear (ex. Smith et al., 2003). Contributing authors should examine this issue of the *CRSQ* or consult the Society's web site for specific examples as well as a more detailed explanation of manuscript preparation. Frequently-used terms can be abbrevi-

ated by placing abbreviations in parentheses following the first usage of the term in the text, for example, polyacrylamide gel electrophoresis (PAGE) or catastrophic plate tectonics (CPT). Only the abbreviation need be used afterward. If numerous abbreviations are used, authors should consider providing a list of abbreviations. Also, because of the variable usage of the terms "microevolution" and "macroevolution," authors should clearly define how they are specifically using these terms. Use of the term "creationism" should be avoided. All figures and tables should be cited in the body of the text, and be numbered in the sequential order that they appear in the text (figures and tables are numbered separately with Arabic and Roman numerals, respectively).

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Margulis, L. 1971a. The origin of plant and animal cells. *American Scientific* 59:230–235.

Margulis, L. 1971b. *Origin of Eukaryotic Cells*. Yale University Press, New Haven, CT.

Hitchcock, A.S. 1971. *Manual of Grasses of the United States*. Dover Publications, New York, NY.

Walker, T.B. 1994. A biblical geologic model. In Walsh, R.E. (editor), *Proceedings of the Third International Conference on Creationism* (technical symposium sessions), pp. 581–592. Creation Science Fellowship, Pittsburgh, PA.

7. Tables. All tables cited in the text should be individually placed in numerical order following the reference section, and not embedded in the text. Each table should have a header statement that serves as a title for that table (see a current issue of the *Quarterly* for specific examples). Use tabs, rather than multiple spaces, in aligning columns within a table. Tables should be composed with *14-point type* to insure proper appearance in the columns of the *CRSQ*.

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Submission of letters regarding topics relevant to the Society or creation science is encouraged. Submission of letters commenting upon articles published in the *Quarterly* will be published two issues after the article's original publication date. Authors will be given an opportunity for a concurrent response. No further letters referring to a specific *Quarterly* article will be published. Following this period, individuals who desire to write additional responses/comments (particularly critical comments) regarding a specific *Quarterly* article are encouraged to submit their own articles to the *Quarterly* for review and publication.

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Occasionally, the editor will invite individuals to submit differing opinions on specific topics relevant to the *Quarterly*. Each author will have opportunity to present a position paper (2000 words), and one response (1000 words) to the differing position paper. In all matters, the editor will have final and complete editorial control. Topics for these forums will be solely at the editor's discretion, but suggestions of topics are welcome.

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All book reviews should be submitted to the book review editor, who will determine the acceptability of each submitted review. Book reviews should be limited to 1000 words. Following the style of reviews printed in this issue, all book reviews should contain the following information: book title, author, publisher, publication date, number of pages, and retail cost. Reviews should endeavor to present the salient points of the book that are relevant to the issues of creation/evolution. Typically, such points are accompanied by the reviewer's analysis of the book's content, clarity, and relevance to the creation issue.

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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* is a peer-reviewed technical journal. It has been gradually enlarged and modified, and is currently recognized as one of the outstanding publications 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 a research and publication society, and also engages in various meetings and promotional activities. There is no affiliation with any other scientific or religious organizations. Its members conduct research on problems related to its purposes, and a research fund and research center are 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.

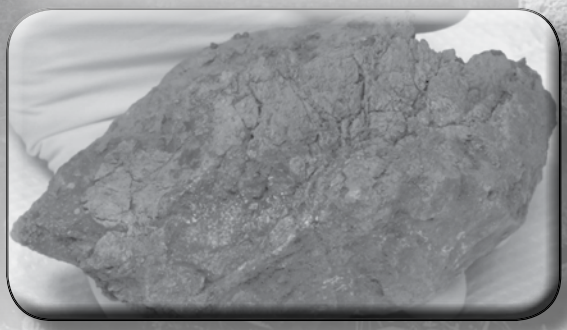
Membership—Voting membership is limited to scientists who have at least an earned graduate degree in a natural or applied science and subscribe to the Statement of Belief. Sustaining membership is available for those who do not meet the academic criterion for voting membership, but do subscribe to the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

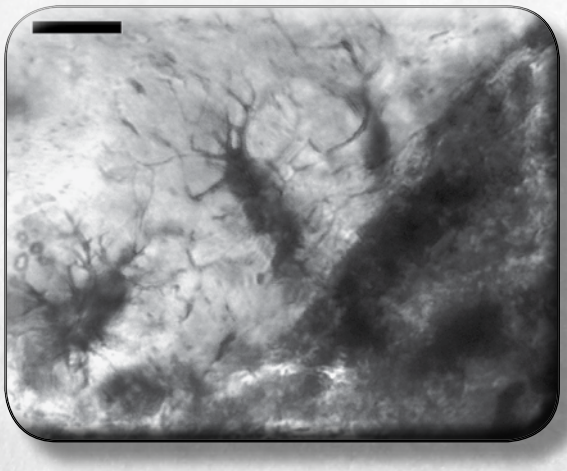
1. The Bible is the written Word of God, and because it is inspired throughout, all its assertions are historically and scientifically true in all the original autographs. To the student of nature this means that the account of origins in Genesis is a factual presentation of simple historical truths.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

iDINO II

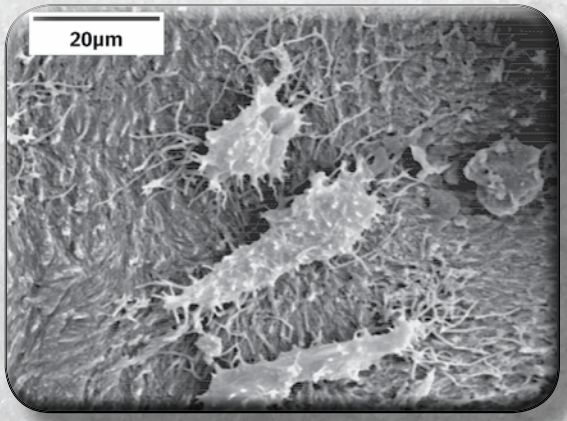
Investigation of Dinosaur Intact Natural Osteo-tissue



A fragment of the *Triceratops* brow horn. Fragments, such as this one, still contain tissue and cells.



Microscopic examination of tissue extracted from a *Triceratops* horn reveals bone cells still present.



Electron microscope picture of intact bone cells still in tissue extracted from a *Triceratops* horn.

How can pliable, stretchable tissue survive inside dinosaur fossils for over 65 million years?

How can this tissue still contain intact cells and even dinosaur proteins?

How can this fragile biological material survive for so long?

The answer to these questions directly challenges the current, evolutionary-biased, geologic timescale.

The Creation Research Society began its iDINO research initiative for the purpose of studying soft tissue in dinosaur fossils. The first phase of the project detected pliable, unfossilized tissue in a brow horn of a *Triceratops*. Within this tissue were intact osteocytes (bone cells). Some results from the iDINO project have been published in a technical microscopy journal and presented at an international microscopy conference. The Spring 2015 issue of the *Creation Research Society Quarterly* also features a special report of the iDINO project. Plus, to further spread the important information about soft tissue, the Society is developing a video (Echoes of the Jurassic).

The **second phase** of the project (iDINO II) will look more extensively at the process of tissue preservation. Evolutionists have offered various theories of how this tissue could survive for millions of years. iDINO II will methodically investigate these preservation claims, assessing their plausibility.

The iDINO results have already provided a strong challenge to the evolutionary worldview. More extensive and detailed examination may provide even stronger evidence that the age of dinosaur fossils is far less than 65 million years. To this end, the Society continues to seek those willing to fund this project with either one-time gifts or monthly donations.

For more information contact us at (928) 636-1153 or crsvarc@crsvarc.com.

Also visit http://tinyurl.com/nphm2c4 for project updates and details.