EVIDENCE FROM BEYOND THE EARTH FOR A YOUNG EARTH

Introduction. Conventional theory dates the solar system at 4.6 billion years, and the universe at more than 10 billion. Long chronologies exist for the earth, other planets, sun, other stars, the solar system, Milky Way Galaxy, other galaxies, and the universe. This chronological array is often taken as irrefutable confirmation of old age. Yet these chronologies are based ultimately on the earth's presumed evolutionary age, which in the final analysis derives from the geological chronology of Charles Lyell.

Partly for political reasons (Grinnell, 1976, p. 68), Lyell discredited the Mosaic chronology, and the chronology resulting from a century of radiometric studies is not substantially different from Lyell's chronology (Henry, 2003, pp. 165, 167-170). **Positive evidence also exists for a short chronology and "recent" creation.** The phenomena discussed below severely constrain the age of the solar system and thus of the earth, implying an age of order as low as millennia.

RAPID DECAY OF PLANETARY MAGNETIC FIELDS

Physicist Thomas Barnes showed that the geomagnetic field is decaying with a half-life of 1400 years (Barnes, 1971, p. 24). Recent data confirm a half-life of about 1465 years (Humphreys, 2002, pp. 3-4). This implies a young earth, since the earth at 4.6 billion years would have no magnetic field left. Anti-creationists fault Barnes with inferior credentials (Vickers, 1998, p. 1), but this charge discounts his earned master's degree and his authorship of a text on electricity and magnetism published by a major press (Barnes, 1965).

Old-age advocates theorize that geomagnetism comes from molten minerals circulating in the earth. High temperature makes the minerals ionize, and circulation of the ions produces a non-decaying magnetic field. Man-made electric current from a generator or "dynamo" also produces magnetism, so by analogy a "dynamo effect" causes geomagnetism (Bloxham and Gubbins, 1989, p. 68; Carrigan and Gubbins, 1979, pp. 119-120). Barnes showed this is not true, and that geomagnetism is from a decaying electric current. This current presumably was installed in the earth during the creation week and began decaying because of the curse on the ground (Barnes, 1983, pp. 14, 27-28, 38, 130-131).

The Earth's Magnetic Field Is Weakening Rapidly

Magnetic field decay implies an earth lifetime of the order of 10,000 years (Barnes, 1983, pp. 53-54; Carrigan and Gubbins, 1979, pp. 123, 125), since much farther back than that, core heating associated with the high level of magnetism would destabilize the earth's interior. Overall, the geomagnetic field has lost about 15% of its energy since the first measurements in the early 1800s (Humphreys, 2002, p. 1), with a decay of roughly 1% per decade (Bloxham and Gubbins, 1989, p. 70).

From 1970-2000, the net loss was about 1.41%, confirming Barnes' earlier claim (Humphreys, 2002, p. 3), and contradicting descriptions of the field as "self-sustaining" with no energy loss (Carrigan and Gubbins, 1979, pp. 119, 120). "In the next two millennia, if the present rate of decay is maintained, the [strength] of the field should reach zero" (Bloxham and Gubbins, 1989, p. 71).

Old age advocates respond that though the field is decaying now, it has been regenerated in the past by "field reversals." However, these reversals are associated with intense seismic activity during the Flood (Humphreys, 1990, pp. 129).

Coe and Prevot (1989, p. 292) and Coe et al. (1995, p. 687) confirmed that magnetic reversals have occurred rapidly rather than over hundreds of millions of years. Further, such reversals were superimposed on the secular decay trend studied by Barnes. **Evidence for reversals does not change the conclusion that magnetic field decay severely constrains the earth's age.**

Planetary Magnetic Fields Imply a Millennial Creation Age

The dynamo theory circumvents this age constraint, but has not led to real understanding of the earth's field or other planetary fields. Before the Voyager flybys of Uranus and Neptune, "the terrestrial case [with the assumption of a dynamo] seemed to serve as a good guide to how planetary interiors should work" (Kerr, 1989, p. 1450). These planets were found to have a magnetic axis severely inclined to the rotational axis, making it virtually impossible that the magnetic field of either planet could be from a dynamo.

Theorists then proposed that Uranus and Neptune had suffered relatively recent catastrophes to produce their unexpected features, but this idea has been discredited (Kerr, 1989, p. 1450). Presumably the Uranian and Neptunian fields, like that of the earth, are due to rapidly decaying electric currents.

Naturalistic models for Mercury's origin lead to the conclusion that its core is now solid, leaving no possibility of a dynamo (Fix, 1999, p. 204). Yet Mercury has an "intrinsic" magnetic field (Hubbard, 1984, p. 203), that is, a field existing with no dynamo. By conventional theory, Mercury should therefore have no magnetic field (Hubbard, 1984, p. 207), and its discovery was a "surprise" (Morrow, 1974, p. 52). But if Mercury has a dynamo, then "the planet has a liquid metallic core," (Fix, 1999, p. 204), a contradiction of theory.

Mercury's field is predicted to decay about 5% between the Mariner 10 mission in 1975 and the Messenger mission flyby in 2011 (Humphreys, 2004, p. 9). **If this prediction is true, Mercury's field is decaying faster than the earth's, implying a Mercury lifetime, and a lifetime for the solar system and the earth, of the order of millennia.**

RAPID DISSIPATION OF PLANETARY RINGS

A puzzle for evolutionary chronology began with Voyager 1's 1980 flyby of Saturn's rings. Telescopes before then provided little ring detail; planetary rings supposedly had changed little since the emergence of the solar system from the primordial nebula -- a vast cloud of gas and dust -- 4.6 billion years ago (Northrup and Connerney, 1987, p. 124; Pollack and Cuzzi,

1981, pp. 117, 125-126, 127, 129; Soderblom and Johnson, 1982, p. 101). "Everyone had expected that collisions between particles in Saturn's rings would make the rings perfectly uniform" (Pasachoff, 1985, p. 429).

Jeffreys (1916, p. 84) had claimed that "the frequency of collision [of ring particles] is very great, and ... on account of the loss of relative motion at every collision, the rings must long ago have reached a state in which all the particles are moving in very accurate circles, all in the same plane" (Jeffreys, 1920, p. 295; Alexander, 1962, p. 320).

This view arose from belief in the rings' great age (Kerr, 1985, p. 1377), but Voyager 1 showed that the rings are highly structured and probably young (Burns et al., 2002, p. 73). There was more structure than could be expected to persist over 4.6 billion years, unless all ring-binding forces were accounted for. Efforts to locate sufficient binding forces have failed, and a "growing number [of astronomers] believe that the rings of Saturn are constantly ... changing due to fragmentation of moonlets and input of new ring particles" (Hartmann, 1991, p. 253; NASA, 2000, p. 1; Burns et al., 2002, p. 73).

However, there remains a reluctance to associate ring change with ring dissipation (Hartmann, 1991, pp. 252-253), since this could imply a young solar system. This reluctance did not exist before the ascendancy of evolutionary chronology (Brush et al., 1983, p. 7). Then Saturn's rings were acknowledged to be rapidly changeable and possibly dissipating. Space probes have rediscovered rapid ring change and dissipation. For Jupiter's rings, "[Ring] particles should last only a very short time -- perhaps only a few thousand years ..." (Fix, 1999, p. 270; Pollack and Cuzzi, 1981, p. 129).

Of Saturn's rings and planetary rings generally, "it now appears that the length of time for planetary rings to dissipate is relatively short" (Fix, 1999, p. 274; Eberhart, 1986a, p. 84). As for Uranus' rings, "The thin outer atmosphere of Uranus extends into the rings, so it should slow down very tiny dust particles and cause them to sink into the inner atmosphere in a few thousand years or less ... Collisions between ring particles ... slowly [make] the ring wider" (Fix, 1999, pp. 289-290; Esposito, 1987, p. 15).

Saturn's Rings Have Been Widening Rapidly

Since Jupiter's rings have dissipation times of a few millennia, and Uranus' rings maybe less, could Saturn's rings be dissipating this fast? Saturn's rings have little matter, "only about a millionth of the mass of our moon" (Snow, 1984, p. 157), similar to that of smaller asteroids such as 243 Ida or 253 Mathilde (Williams, 2000a, p. 1). Their small mass suggests that the rings could "empty out" fairly quickly. Indeed, Jupiter's rings are thought to be in part the product of the dissolution of two moons, Adrastea and Metis (Goldsmith, 1985, p. 461), both with masses comparable to the mass of Saturn's rings (Williams, 1999a, p. 1).

Alexander (1962, pp. 84-441) documented 350 years of widening in Saturn's A and B rings (Corliss, 1979, pp. 466-471). In the 1850s Otto Struve assessed observations from the previous two centuries which indicated ring-spreading into Saturn at a rate of some 60 miles per year (Alexander, 1962, p. 184; Slusher, 1980, p. 71; Struve, 1960, p. 21). But with hypothetical assumptions from the popular nebular hypothesis which claimed a naturalistic origin, an old age, and little change in the solar system presently, Struve's analysis was considered questionable (Brush et al., 1983, p. 5). So strong had belief in the nebular hypothesis become that Taylor (1883, p. 660) inconsistently claimed ring spreading was compatible with it.

However, Maxwell had shown that Saturn's rings are particulate and not rigid disks or liquid. Maxwell's theoretical predictions were confirmed by observation (Brush et al., 1983, p. 24; Alexander, 1962, p. 187), and Maxwell (1859, pp. 353, 373-374) considered Struve's analysis consistent with theory.

Nevertheless, Struve (1883, pp. 17-20) had failed to measure continued ring spreading, and Lewis (1895, p. 385) concluded that ring observations were not "accordant" because of "the great difficulty in making these measures." But he also stated that Saturn's rings were "certainly" not undergoing long-term change, even though his data (Lewis, 1896, p. 203) showed C-ring spreading. Lewis thus laid the groundwork for Jeffreys' concept of very old rings.

Saturn's C Ring Formed Recently

Saturn's most prominent rings are the A, B, and C rings (Horn, 1996, p. 663; Snow, 1984, p. 156). However, the C ring was not visible until the 1800s: "William Herschel, the foremost astronomical observer of his time (1738-1822), makes no mention of the [C ring] in any of his writings, and it is inferred that it was not then a conspicuous object. If this inference be correct, we must conclude that this ring is rapidly growing, and that the rings of Saturn are probably comparatively recent introductions to the solar system" (Dupuis, 1910, pp. 166-167).

Yet the C ring now can be seen "with telescopes of moderate size" (Baker, 1950, p. 222). Since Herschel's telescopes were among the best of his day, with Saturn a "favourite object of study" (King, 1955, p. 133), one is led to conclude that he missed the C ring because it was absent. The first recorded observation was in 1848 (Fix, 1999, p. 270; Baker, 1950, p. 222). **Thus one of the three prominent rings of Saturn has evidently developed since the early 1800s.** The inner edge of the C ring is approaching the planet (Lewis, 1896, p. 203), and Napier and Clube (1979, p. 457) calculated the rate of approach as 60 miles per year.

The history of C ring observations implies rapid ring spreading and dissipation. The inner edge of the B ring is now 91,975 km from the center of Saturn, and the inner edge of the C ring is at 74,658 km (Williams, 1999b, p. 1). Thus the width of the C ring is 17,317 km, or about 15,000 km, a width which developed since about 1850. This implies an infall of ring particles over some 100 km/yr, or 60 mi/yr, in agreement with the in-spreading computation of Napier and Clube.

Like Jupiter's and Uranus' rings, Saturn's rings appear to be decaying in a millennial time-frame. Ring dissipation does not require millions of years. When planetary rings were thought to be old, they were taken as evidence for an old solar system. Intimation of their youth therefore obliterates a prop of the conventional chronology.

Baum (1954, p. 194) reported "dusky nebulous matter in the form of an additional ring" beyond ring A, with "a diffuse fringe [extending] the ring system beyond its normal limits." Baum may have been seeing one or more of the now-recognized tenuous outer rings (the F, G, and E rings), or he may have been seeing dissipation of A ring material outward, and if ring particles "reach the outer edge of the rings, they leave the ring system" (Fix, 1999, p. 274).

Feibelman (1967, p. 793) likewise reported "an extension or at least a gradual tapering of the outer edge of the A ring." **Thus it appears that the A ring is losing particles to the outer F, G, and E rings, and then to space beyond.** How trustworthy are such ground-based observations? Dismissing them as subjective phenomena would be premature. In fact existence of the F ring had been theorized before the Voyager flybys (Jeffreys, 1947, p. 267), though Jeffreys discounted this prediction.

Inside the C ring, "the possibility of a faint ring ... was raised some time ago [from ground-based observations], and this D ring was actually found" (Snow, 1984, p. 156; Alexander, 1962, pp. 196-197, 235). **Ground-based discovery of the D ring before its Voyager detection shows validity for ground-based ring-spreading observations.**

Like the outer F, G, and E rings, the D ring seems to be composed of small particles. These particles are spiralling into Saturn: "individual ring particles work their way slowly inward ... If they move inward far enough, they encounter the tenuous outer layers of the planet's atmosphere and are destroyed" (Fix, 1999, p. 274). Ring particles of Jupiter and Uranus also show this behavior (Hartmann, 1991, p. 243; Fix, 1999, p. 289). **To sum up, particles in outer rings dissipate into space; those in innermost rings fall toward the planet.**

Efforts to Save Long Ring Chronologies Have Failed

The Uranian and Jovian ring systems were discovered shortly before the Voyager views of Saturn's rings, and according to NASA appeared too young to exist in an old solar system: "The theory that explained how Saturn's rings could persist through 4.6 billion years of solar system evolution also explained why Saturn was the only planet that could have a ring. Then those theories had to be revised to account for the rings of Uranus. The revisions implied that Jupiter would not have a ring. Now Jupiter has been found to have a ring and we have to invent a theory to explain it" (Tippets, 1979, p. 185). The older unworkable theory was the orbital resonance hypothesis (Alfven, 1968, pp. 75, 76-77).

When Saturn was the only known ringed planet, orbital resonances, due to moons of Saturn gravitationally acting on ring particles, could account for the limited ring structure visible from earth. The resonance hypothesis "had been worked out with fewer than a half-dozen rings [of Saturn] known. The ring structure the Voyagers discovered is too complex to ... explain thousands of rings" (Pasachoff, 1985, p. 430). "A thousand rings seemed a monumental problem for theorists. They had run out of resonances long ago" (Elliot and Kerr, 1984, p. 137; Thompson, 1976, p. 84). NASA's conclusion: "No theory has yet been developed that explains how all three of these planets could have rings for so long," i.e., 4.6 billion years (Tippets, 1979, p. 185).

The "shepherd moon hypothesis" was then proposed to give planetary rings a long lifetime. Shepherd moons were supposed to corral ring particles, keeping entire ring systems together over eons (Alfven, 1968, p. 77; Trulsen, 1972, pp. 333, 335, 336). This theory was once used to account for *all* rings of Saturn, Jupiter, and Uranus (Hartmann, 1991, pp. 250-251, 263; Goldsmith, 1985, p. 461; Pasachoff, 1985, p. 441).

After the Voyager 2 flyby of Uranus' rings in 1986, NASA scientist Bradford Smith stated, "We are assuming [the existence of shepherds], because we don't know any other way to do it [i.e., preserve the rings]" (Eberhart, 1986b, p. 73). Since then, conventional opinion on the antiquity of planetary rings has changed due to difficulties in the shepherd moon theory. Rings are no longer viewed as debris from the solar nebula with an age of billions of years (Cuzzi, 1985, p. 22). Instead the rings have formed by the fracturing of one or more moons, and therefore must have formed "recently" (Fix, 1999, p. 275; Podolak et al., 1993, p. 1120). "Recently," however, is a relative term, and may signify millions of years (Esposito, 1987, p. 15; Sobel, 1994, p. 88).

Nevertheless, shepherd moons continue to be presented as the reason planetary rings exist (Burns et al., 2002, p. 70). Though ring decay occurs, it is still not acceptable to allow this fact to imply a young solar system, and shepherds are invoked to extend a ring's chronology.

This means that rings must be simultaneously decaying, yet confined by shepherds: "[Planetary rings] tend to spread ... Sometimes planetary rings are kept in place by the gravitational force of shepherd moons. Saturn has a very intricate ring system with lots of moons helping to keep its rings together" (Masetti and Mukai, 2000, p. 1). This is false -- "lots" of shepherds have not been found. Another false claim is that the "`shepherding' effect has been found to confine a number of rings in the solar system" (NASA, 1997, p. 3). Out of hundreds of thousands of ringlets in planetary ring systems, only a few have been found with nearby moonlets interpreted as shepherds. Most notable are the F ring of Saturn, Jupiter's ring system, and Uranus' thick ring. As mentioned above, the last two are now viewed primarily as rapidly decaying, despite putative shepherding effects.

Where Are the Shepherd Moons?

"Shepherd moons" such as Prometheus and Pandora, moons of Saturn near the F ring, have been photographed (Ruben, 2002, p. 53), but mere existence does not confirm they are acting as shepherds. Moons once described as "shepherds" seem to be disintegrating into the ring structure. This is acknowledged for Jupiter and Uranus (Fix, 1999, pp. 270, 289).

During the 1995 Saturn ring plane crossing, the Hubble Space Telescope looked for new satellites. Two were announced as new in a press release and were designated 1995S1 and 1995S2. They turned out to be the already-known moons Atlas and Prometheus. Even more interesting, five other bodies, 1993S3 to S7, were observed, but were later "hypothesized to be shattered moonlets" in the F ring (Williams, 1997, p. 1). **Conclusion: bodies perceived as "shepherd" moons of Saturn are undergoing disintegration within the ring structure.**

Discussing these fragmented satellites, Philip Nicholson of Cornell University said, "[O]ne scenario for the

origin of Saturn's ring system is that it is made up of countless fragments from several pulverized moons. ... [T]he new objects orbit Saturn near the narrow F ring, which is a dynamic transition zone between the main rings and the larger satellites. [Fragmented moons would eventually] spread around the moon's orbit to form a new ring" (Isbell and Villard, 1995, p. 2).

Showalter (1992, p. 177) surmised that Saturn's narrow G ring, thought to be composed of very fine dust, may in fact be "the `decaying corpse' of a moon destroyed by meteoroid impact." Since the F ring is a "dynamic transition zone" where satellite fragmentation is likely to occur, what is the possibility that the so-called "shepherds," Prometheus and Pandora, could be undergoing the same type of dissolution?

A stunning observation answered this question. The reason the previously mentioned satellite 1995S2 was not initially recognized as Prometheus is that its location did not match the position expected. Prometheus had "slipped in its orbit by 20 degrees from the predicted position ... a consequence of a `collision' of Prometheus with the F ring, which is believed to have occurred in early 1993" (Isbell and Villard, 1995, p. 2).

Thus Prometheus is not so much "shepherding" the F ring as mutually interacting with it, sometimes colliding with it, and likely disintegrating as a result. It is doubtful that the so-called shepherds of the F ring ever fulfilled that function. In 1980, Voyager 1 detected a twisting or "braiding" in the F ring attributed to Prometheus and Pandora, but Voyager 2 in 1981 detected "no signs of braiding in the F ring" (Pasachoff, 1985, p. 430; Pollack and Cuzzi, 1981, p. 119). Thus the "shepherds" Prometheus and Pandora are not shepherds after all.

Since the F ring is a "dynamic transition zone," it is most likely that Prometheus and Pandora are fragments of larger bodies en route to further disintegration, the same process thought to have produced the moonlets 1995S3 to S7. Prometheus and Pandora are not spherical and have an irregular shape (Williams, 1999c, p. 1). They seem either to be captured asteroids or fragments of a larger moon. The F ring itself is expected to widen over time, eventually dissipating altogether (JPL, 2002, p. 1).

The Voyager missions demolished the belief that planetary rings must be old. The Cassini probe began orbiting Saturn in 2004. What additional evidence is it returning of rapid ring dissolution and youth?

LUNAR RECESSION

According to Genesis 1:14-18, God spoke the moon into existence as a unique celestial body on Day Four of the Creation Week.

Opposing the Genesis account are naturalistic theories of lunar origin: (1) the fission theory (the "spouse" theory), popularized first by George Darwin (1898, pp. 278-286), son of Charles Darwin; (2) the capture theory ("daughter" theory); (3) the accretion theory ("sister" theory); and (4) the impact theory. The impact theory is now most favored because the other theories "have serious flaws" (Fix, 1999, pp. 190, 192).

The capture theory has been discredited because of the improbability of earth's capturing an approaching moon-size object. Rather than explaining the origin of the moon itself, this theory merely displaces the problem of lunar origin to an indeterminate point far from earth.

The accretion theory claims that the moon coalesced from debris remaining from the solar nebula in close orbit about the earth. The accretion theory, sometimes called the "double planet theory," says that the earth and the moon formed in tandem from the solar nebula. If this theory were true, the earth and the moon should have similar structure and composition.

As might be expected from the creation of the moon as a unique heavenly object, its composition does not match the earth's. Indeed, the accretion theory has been discredited because of difficulty in explaining how debris can coalesce, and also because of the problem of "explaining why the abundance of iron in the Earth and the Moon is so different" (Fix, 1999, p. 191; Hammond, 1974, p. 911).

The fission theory claims that the moon coalesced from debris spinning off the presumably molten earth eons ago. The impact theory claims that a Mars-size asteroid once impacted the earth, with debris being thrown upward by the impact and eventually coalescing into the moon. The fission and impact theories both require that the debris forming the moon begin coalescing at or near earth's Roche limit.

The Roche limit is the distance from a central body, such as a planet, inside of which orbiting debris cannot coalesce. The gravitational force of the central body on an orbiting particle is stronger on the particle's near side than on its far side. Within Roche's limit, this differential gravitational force is greater than the particle's own self-gravitation, and particles break apart rather than joining.

An artificial satellite can exist within Roche's limit if non-gravitational cohesive forces hold it together, but once torn apart into smaller pieces, the pieces cannot rejoin. Saturn's rings are evidently fragments of moons once orbiting Saturn. Forces due to collisions, or disruptive forces within the moons, tore the moons apart. Before they fragmented, cohesive forces held the moons together, but once disintegrated, they could not re-form. Similarly, earth's moon could never form inside the Roche limit from debris due to fission.

Even the impact theory leaves moon's origin "still unresolved," and it was adopted "not so much because of the merits of theory as because of the ... shortcomings of other theories" (Ruzicka et al., 1998, p. 851; Lissauer, 1997, p. 328). Lunar origin theories have a history of being accepted with fanfare, then being quietly dropped as unworkable. Indeed, Hartmann (1972, p. 127) quipped, "The moon seems a highly unlikely object. Theoreticians have been led by frustration on more than one occasion to suggest facetiously that it does not exist" (Lissauer, 1997, p. 327).

The Moon's Maximum Age Is Less Than 4.6 Billion Years

The moon was never at Roche's limit, but was positioned or "set" in the firmament (Genesis 1:17) at approximately its

present distance from earth. The moon is very slowly receding from the earth. Below we compute the time which would hypothetically be required for the moon to recede from Roche's limit to its present position. The recession rate dr/dt of the moon (Darwin, 1898, p. 274; DeYoung, 1990, p. 81) is

$$\frac{dr}{dt} = \frac{k}{r^6} \qquad (1)$$

where r is the semimajor axis of the moon's orbit, t is time, and k is a proportionality constant. When $t = 0$, $r = r_0$.

To compute the moon's recession time to its present orbit, we first integrate equation (1). Over the time interval 0 to t, the moon's distance from the earth increases from Roche's limit r_0 to its present orbit at distance r. Integrating t and r over these intervals gives

$$t = \frac{1}{7k}(r^7 - r_0^7) \qquad (2)$$

in which t is the maximum age of the earth-moon system. The present value of r is 3.844 x 10^8 m. For an object orbiting a planet, Roche's limit r_0 is

$$r_0 = 2.4554\, R \left[\frac{\rho_p}{\rho_m}\right]^{1/3} \qquad (3)$$

where R is the radius of the central body (the earth); ρ_p is the density of the central body; and ρ_m is the density of the orbiting body, in this case the moon (Whitcomb and DeYoung, 1978, p. 42). With R = 6.3781 x 10^6 m for the earth; ρ_p = 5515 kg/m^3; and ρ_m = 3340 kg/m^3, we find that r_0 = 1.84 x 10^7 m. This is less than 5% of the moon's current orbital radius.

From equation (1), the proportionality constant k is the product of the sixth power of the distance r, and the current recession rate. The present value of the recession rate is 4.4 ± 0.6 cm/yr, or (4.4 ± 0.6) x 10^{-2} m/yr (Lang, 1992, p. 31). Therefore, k = 1.42 x 10^{50} m^7/yr. With this value for k, the right hand side of equation 1 equals the present recession rate dr/dt, when r = the moon's current orbital radius.

From equation (2), **the time for the moon to recede from r_0 to r is 1.3 billion years. Without introducing tidal parameters, this is the moon's highest allowable evolutionary age,** and is similar to DeYoung's (1990, p. 82) estimate. Though long relative to biblical chronology, it is a serious challenge to the belief that the moon is 4.6 billion years old (Munk and MacDonald, 1960, p. 202), as Baldwin (1965, p. 40) noted:

"Jeffreys' early studies of the effects of tidal friction [the cause of lunar recession] yielded a rough age of the Moon of 4 billion years. ... Recently, however, Munk and MacDonald have interpreted the observations to indicate that tidal friction is a more important force than had been realized and that it would have taken not more than 1.78 billion years for tidal friction to drive the Moon outward to its present distance from any possible minimum distance. This period of time is so short, compared with the age of the earth, that serious doubts have been cast upon most proposed origins and histories of the moon."

Efforts To Save a Long Lunar Chronology Have Failed

One response to the chronological challenge of recession has been the impact theory, in which lunar material originates within Roche's limit but is quickly ejected beyond it. The impact theory in turn is grounded in an older concept, the "resonance theory," which claims that the moon was never actually at Roche's limit. According to this theory, the moon is currently receding, but was once approaching the earth as part of a series of alternating recession/approach events as old as the moon's conventional age (Hansen, 1982, p. 457; Brush, 1983, p. 78). **The resonance theory, however, presumes conventional age rather than proving it, so is no support for evolutionary chronology.**

Another response has been to minimize the lunar recession rate. The current recession rate is 3.8 cm/yr according to NASA (Williams, 2000b, p. 2), which is the *lower* end of the range of lunar recession rates discussed above, and Fix (1999, p. 182) cites a value of only 3 cm/yr.

A third response is to employ adjustable tidal parameters to stretch recession chronology into harmony with the conventional solar system lifetime (Finch, 1982, pp. 113-114; Dalrymple, 1991, pp. 51-52).

Naturalistic lunar origin theories assume the moon to have been once close to earth. If the moon's distance r had been much smaller than now, equation (1) shows that the recession rate dr/dt "must have been much larger in earlier times" (Verhoogen, 1980, p. 22). George Darwin (1898, p. 274) stated, "Thus, although the action [rate of lunar recession] may be insensibly slow now, it must have gone on with much greater rapidity when the moon was nearer to us." Using equations 2 and 3 above, with the conventional age of 4.6 billion years for the earth-moon system, we can compute how far the moon should have receded from Roche's limit over that time. Using r_0 = 1.84 x 10^7 m, k = 1.42 x 10^{50} m^7/yr, and t = 4.6 x 10^9 yr, we find that r = 4.7 x 10^8 m. This is 20% higher than the actual distance of the moon from the earth. Conclusion: the earth-moon system cannot be 4.6 billion years old.

THE AGE OF PLANETARY HEAT

The planets did not evolve from a common source, but were individually or "specially" created (as wandering "stars," cp. Genesis 1:16). Special creation therefore permits the possibility of diversity among the planets, but naturalistic origins theory leads to the expectation of overriding commonalities.

One point of diversity involves the heat output of the giant planets -- the "Jovian planets" Jupiter, Saturn, Uranus and Neptune. All planets give back into space the heat they receive from the sun, but most of the giant planets give off much more heat than this. The excess is 67% for Jupiter, 78% for Saturn, and 170% for Neptune (Henry, 2001, p. 87).

Naturalistic origins theory envisions solar system development from the solar nebula over 4.6 billion years. As high-energy nebular material collected into planets, planets became molten, and the giant planets because of their huge size continue to give off this primordial heat (Trefil, 1985, p. 125;

Hartmann, 1991, p. 267; Robbins and Jeffreys, 1988, p. 158). This theory is questionable (Podolak et al., 1993, p. 1112). There is no reason to assume that the moon or planets initially had hot interiors (Urey, 1971, p. 403). Radiohalo evidence shows that the earth was not molten originally (Gentry, 1992, pp. 29-33; Gentry, 1968, p. 1230; Gentry et al., 1973, p. 282).

Other explanations for excess heat are gravitational contraction (Pasachoff, 1985, p. 417) and separation of materials (phase separation) in planetary interiors. However, models of planetary interiors are "theoretical" (Nellis et al., 1995, p. 1249), representing conditions that "cannot be replicated in laboratories" (Ouyed et al., 1998, p. 368). The Voyager flybys confirmed that Jupiter is in "strict hydrostatic equilibrium," so cannot be contracting (Hubbard, 1984, p. 263; Podolak et al., 1993, p. 1114).

Since Jupiter is the most massive planet, there is virtual certainty that other giant planets cannot be gravitationally contracting. Jovian "global oscillation" data confirm that phase separation is a minor process if occurring at all (Nellis et al., 1995, p. 1251), so phase separation is "unlikely" (Nellis, 2000, p. 89).

Ouyed et al. (1998, p. 369) concur that "gravitational settling by diffusion" cannot "account for Jupiter's excess heat." In short, "existing models for the jovian interior need to be revised" (Alavi et al., 1995, p. 1252), and "all the models of Jupiter (and Saturn) ... are basically incorrect" (Guillot et al., 1995, p. 470).

Further, the three Jovian planets emitting extra heat cannot have been doing so for 4.6 billion years. Bishop and de Marcus (1970, p. 317) computed that even if Jupiter initially had a star-like surface temperature of 20,000 C, the cooling time to its present temperature would have been too brief to satisfy conventional chronology. The reason is that huge convection currents in Jupiter dissipate heat rapidly (Hubbard, 1984, pp. 267-268). Likewise for Saturn, "All cooling calculations to date ... indicate an age about half the age of the solar system" (Saumon et al., 1992, p. 828).

Uranus Has Little or No Excess Heat

A more serious difficulty for conventional chronology is Uranus' unique thermal behavior. It gives off little or no excess heat (Podolak et al. 1993, pp. 1112, 1113; Pearl et al., 1990, pp. 26, 27), thus disproving conventional explanations of excess heat output for other giant planets. "Ground-based and spacecraft observations have revealed large excess energy fluxes from Jupiter, Saturn, and Neptune but a very small excess from Uranus," and there may be "no energy excess" (Pearl and Conrath, 1991, p. 18921).

Yet contrary claims exist: "Uranus and Neptune release more energy than they receive from the sun. ... [T]hey glow with internal heat" (Anonymous, 2000a, p. 24). This type of claim is false and arises from the expectation that the giant planets have evolved toward a similar condition. Naturalistic origins theory considers Uranus and Neptune to be "sister planets," though thermally speaking, "Uranus and Neptune are different" (Abell et al., 1987, p. 333).

Before the 1986 Voyager 2 Uranus flyby, Uranus was thought to be thermally similar to the other giants, emitting up to 30% excess heat (Ingersoll, 1987, pp. 39-40). But "there has been no evidence of an internal heat source (unlike the other gaseous planets)" (Perth Observatory, 2001, p. 1), and "Uranus is different from the other giant planets in that it is not radiating a substantial amount of excess internal heat. ... It is not clear why Uranus has such a low internal heat output compared to the other Jovian planets" (Encyclopeadia Britannica, 2001, p. 4).

Uranus' thermal behavior is a serious challenge to conventional solar system chronology. Its lack of excess heat implies that the conventional heat-producing theory of planetary formation cannot be true, leaving open the possibility that the solar system could be young. "[T]o preserve the billion-year age" of the solar system (Samec, 2000, p. 3), Ouyed et al. (1998, p. 367) proposed deuterium fusion generating heat in the giant planets. Ouyed (2001, p. 1) has since acknowledged that this model does not work.

Uranus and Neptune Are Not "Sisters"

Of the Jovian planets Neptune has the highest ratio of energy emitted to energy absorbed, yet Uranus has the lowest.

Until the 1989 Voyager 2 flyby past Neptune, a mixing model explained the thermal differences between Neptune and Uranus. According to this scenario, "Neptune ... suffered a collision late in its formation that stirred the ice and rock of its interior all the way to the center. That mixing helped break down the stratification that would otherwise have greatly inhibited the heat-driven vertical circulation that now carries heat to the surface.

"Uranus' late hit, on the other hand, was way off center, as evidenced by the way it is lying on its side. That kind of collision might have failed to stir up the deep interior, leaving its heat largely trapped there. Because the rotation period provides one indication of how well mixed the interior is, a Neptunian day of 17 hours [versus 17.2 hours for Uranus] would have implied just the difference in mixing between the two planets ... to explain the difference in heat leaking out" (Kerr, 1989, p. 1450).

This theory was discredited when Voyager 2 found that Neptune's rotational period is only 16 hours, a period too small to imply the mixing that would explain why Neptune radiates significant excess heat but Uranus does not. There is no firm evidence that Uranus suffered the catastrophe of this model, and now, "The substantial difference between the energy balance of Uranus and Neptune is still not completely understood" (Pearl and Conrath, 1991, p. 18930).

For Neptune, as well as Jupiter and Saturn, radioactivity may be a heat source. Radioactivity may supply most of the earth's internal heat, though "nobody knows just how much this heat source produces" (Normille, 1999, p. 1911). Knowledge of radioactivity in Neptune is even scarcer.

Aside from the thermal difference between Uranus and Neptune, these planets differ from the other Jovian planets in at least six other ways (Guillot, 1999, p. 74). **Rather than appearing more alike, the Jovian planets are emerging as increasingly dissimilar, and Uranus' unique thermal behavior continues as a challenge to long chronology.**

OTHER CHALLENGES TO STANDARD DATING

1. Mercury's Atmosphere

Mercury has an atmosphere less than one-trillionth as substantial as earth's. Even this rarified atmosphere should not

exist on Mercury after 4.6 billion years, and its discovery by the Mariner 10 probe was a "surprise" (Morrow, 1974, p. 52). At one time this atmosphere, especially the helium gas, was believed to be atoms of "solar wind" captured from the sun (Murray, 1975, p. 64). But hydrogen is the most common element in the sun, whereas on Mercury "the sparsity of detected hydrogen argues against this origin" (Short, 1975, p. 289).

Mercury's high surface temperatures, peaking at about 430 C (800 F), should have driven its rarified atmosphere away over eons. Conclusion: Mercury is younger than 4.6 billion years.

2. Venus' Heat

Venus has the hottest surface of any planet, but it should have cooled much more over 4.6 billion years (Anonymous, 1980, p. 437). The earliest explanation of Venus' heat was that the substantial Venusian atmosphere blankets the planet, keeping the heat in for eons. But an atmosphere substantial enough to insulate the planet for so long would exist only if Venus had been so hot originally that "its atmosphere would have been lost" into space, being driven off by the heat (Firsoff, 1968, p. 103).

Sagan (1960, p. 352) proposed an atmospheric "greenhouse effect" trapping heat over eons, and this idea was refined into the "runaway" greenhouse concept (Rasool and de Bergh, 1970, p. 1037). However, water is one of the most powerful greenhouse gases, and observations showed "no evidence of water vapor in the lower atmosphere of Venus" (Janssen et al., 1973, p. 994), so the Venusian greenhouse was disproved (Short, 1975, p. 284). Venus appears too hot to be old.

3. Mountains of Venus

Venus' average surface temperature is about 460 C (950 F), hotter than the melting point of lead (328 C or 622 F). At this temperature rocks are not rigid but slightly "plastic." Over billions of years, the crust could not support high mountains, and the mountains could not maintain their steep slopes. However, the Magellan probe found that Venus has fresh-looking mountain slopes and some of the tallest peaks in the solar system, for example, the 8000 m (26,000 ft) Maat Mons (Kerr, 1994b, p. 759; Fix, 1999, p. 214).

Of 75 craters mapped, only one showed signs of aging. One theory to account for the lack of expected aging is that recent lava flooding destroyed the old craters, but why would a planet's volcanism turn off so abruptly and completely? When planetary geologists view the Venusian surface, "they see a newborn babe," a surface "too pristine" to be 4.6 billion years old (Kerr, 1990, p. 912).

4. The Moon's Heat

Based on the idea that the moon started out molten 4.6 billion years ago and has cooled since, opinion used to be that the moon must now be cold throughout (Gamow, 1965, pp. 41-42). Lunar mapping by the Clementine satellite showed that, "Most likely, part of the rock is still molten" (Kerr, 1994a, p. 1666). Indeed, the first lunar astronauts measured a higher heat flow from the moon than expected, indicating that "the Moon's interior is much hotter than most thermal models had anticipated" (Short, 1975, p. 184). Though the moon's heat flow "is 1/3 of that of the Earth, [t]his is surprisingly large for such a small body, which should have cooled more rapidly than the larger Earth" (Fix, 1999, p. 190). Radioactive decay of lunar elements could explain this heat, but such elements have not been detected as required. The straightforward explanation is that the moon has not had time to cool.

5. Transient Lunar Phenomena

A 4.6-billion-year-old moon should be "essentially dead" with no geological activity (Short, 1975, p. 332), and "most scientists have concluded that lunar volcanism has not been possible for some time" (Kitt, 1987, p. 87). Yet through the centuries observers have reported "transient lunar phenomena" (TLP), momentary flashes of light due to eruption of gases (Middlehurst et al., 1968, pp. 5-45).

Many TLP have been sighted "near the crater Aristarchus and around the edges of many of the circular maria," showing that the moon "is not completely dormant" (Kitt, 1987, p. 87; Short, 1975, p. 171). Prior to the first Apollo moon landing, NASA concluded that "the number of [TLP reporting] errors [was] not high" (Middlehurst and Moore, 1967, p. 449). Conclusion: TLP sightings are genuine and not illusions.

Nevertheless, in 1964 when NASA organized a network of amateur lunar observers which reported a TLP in progress, professional opinion was that, "It is far easier to believe that misinterpretations of mundane atmospheric and instrumental effects are responsible" for TLP sightings (Sheehan and Dobbins, 1999, p. 123). But in 1994, about 100 amateur astronomers noticed a 40-minute darkening near the edge of Aristarchus crater; the Clementine lunar satellite was mapping the area, and Aristarchus had really turned redder after the TLP reported by the amateurs (Seife, 1999, p. 22). However, after correcting the Clementine data for lighting geometry and other effects, the evidence for the 1994 TLP faded (Anonymous, 2000b, p. 22).

TLP sightings were vindicated in late 1999 when Leonid meteors crashing on the moon were also sighted as flashes of light (Talcott, 2000, p. 30). **TLP observers seem to be observing the activity of a "young" moon.**

6. Mountains of the Moon

On an old moon, tall mountains should not have survived. However, in places not visible from earth, the Clementine satellite measured elevation ranges as high as 25 kilometers (Kerr, 1994a, p. 1666). Actually, this "lack of isostatic adjustment" has been known for decades (Short, 1975, pp. 73, 75) and is characteristic of a young moon.

7. The Asteroid Belt

Asteroids are chunks of rock and dust mostly between the orbits of Mars and Jupiter. Conventional theory says that

asteroids are debris that did not coalesce into a planet when the solar system formed. Jupiter's gravitational tug supposedly kept the debris from coalescing. This theory does not really work, and to theorists the asteroid belt is a "problem," with current theory "headed towards the dustbin of history" (Lissauer and Stewart, 1993, pp. 1061, 1080, 1081, 1088).

These difficulties have led theorists to speculate that "asteroid belts might not be a common feature among planetary systems otherwise much like our own" (Lissauer and Stewart, 1993, pp. 1081-1082).

Even if formation of the primordial asteroid belt could be explained, there is the problem of how a Jovian protoplanet could clear the belt of debris so as to make it appear as it is today. Though the asteroid belt was once more massive (Chapman and Davis, 1975, p. 553), early Space Age probes showed that it is emptying faster than expected (Lissauer and Stewart, 1993, p. 1081; Robbins and Jeffreys, 1988, p. 124; Beatty, 1994, p. 26).

Opinion used to be that collisions among asteroids are rare, but the 1991 discovery of impact grooves on Gaspra showed that collisions are more frequent than once believed (Veverka et al., 1993, p. 72; Asphaug, 2000, p. 53; Hartmann, 1991, p. 289). Asteroidal collisions form dust which spirals into the sun or, in the case of very small particles, is ejected from the solar system (Kerker, 1974, p. 97). This implies relatively young age for the asteroid belt.

Further, the Yarkovsky effect, a non-gravitational force that sunlight exerts on asteroids, moves them into near-earth orbit faster than had been expected (Chesley et al., 2003, pp. 1739, 1741). The maximum expected lifetime of near-earth asteroids is of the order of a million years, after which they collide with the sun (Farinella, 1994, p. 315). This raises doubts that asteroids originated 4.6 billion years ago, 4600 times more than the near-earth asteroid lifetime.

Asteroid "moons" pose an even more serious age constraint. Tidal effects limit the lifetime of an asteroid's moon to about 100,000 years (Binzel and van Flandern, 1979, p. 905). This fact and the difficulties of "moon" capture led some astronomers to doubt the existence of asteroidal moons (Tedesco, 1979, p. 905). The Galileo probe sighted Ida's moon Dactyl in 1993 (Asphaug, 2000, pp. 51-52), confirming this age constraint.

8. Io's Heat

Jupiter's moon Io was believed to be cold and dead before the 1979 flyby of Voyager 1. Then Voyager 1 observed active volcanoes on Io. This was unexpected; Io had been thought "to have an ancient cratered surface much like that of the earth's moon" (Soderblom, 1980, p. 91). The volcanism means that Io has lots of internal heat. Tidal-heating accounts for "at most 40% of the estimated heat flow," and this is about 200 times larger than the contribution from radioactivity (Showman and Malhotra, 1999, pp. 82, 83).

There is thus no known source of the heat; apparently Io is losing heat generated at some earlier time. This heat cannot be from the solar nebula, since over 4.6 billion years the accumulated heat would have been lost long ago. The heat accumulation must be recent. This conclusion challenges conventional chronology, since it implies that the internal heat of moons and planets could not have originated 4.6 billion years ago.

9. Europa's Heat

Jupiter's moon Europa was believed to be a frozen world until the Voyager views, which showed smooth plains between craters evidently filled in with liquid water from below. Over the conventional time scale the heat necessary to melt the ice would have disappeared long ago.

Tidal heating and "all known mechanisms" fail to account for the heat still present (Anonymous, 1999, p. 27; Spencer et al., 1999, p. 1514). Conclusion: Europa appears to be young (Showman and Malhotra, 1999, p. 81; Johnson, 2000, p. 43).

10. Ganymede's Magnetic Field

Jupiter's moon Ganymede has a magnetic field, but the core is too hot for permanent magnetism to exist. The field is conventionally theorized to result from a dynamo (Sarson et al., 1997, p. 1106), but a dynamo requires a very hot interior, and Ganymede is so small it would have cooled in a small fraction of 4.6 billion years.

Either (1) Europa is old, cold, has no dynamo, and its magnetic field is from some other (non-dynamo) source; or (2) its magnetism is from a dynamo, which requires that it be hot, and therefore young. The first conclusion violates the conventional dynamo theory of magnetic fields; the second conclusion violates the conventional chronology (Johnson, 2000, p. 47).

11. Titan's Atmosphere

Saturn's moon Titan has an atmosphere rich in methane gas, CH_4. Methane molecules are large enough that, according to planetary scientist Tobias Owen (1982, p. 98), Titan's atmosphere "should not have escaped from Titan over the history of the solar system." The Cassini probe flew by Titan in 2004, however, and detected less methane than expected (Kerr, 2004, p. 1676; Kerr, 2005, p. 330).

The methane is not stable, breaking down to produce hydrogen gas which escapes rapidly into space, as confirmed by the Huygens probe which landed on Titan in 2005. In a reversal of his 1982 statement, Owen now states that, were Titan 4.6 billion years old, the methane "would have all disappeared," unless replenished from an internal source (Leicester, 2005, p. 7). No internal source is known, and Titan appears to be young.

Conclusions. The phenomena discussed herein limit the age of the solar system, and thus of the earth and the universe, to much less than 4.6 billion years. Decay rates for planetary magnetic fields and planetary rings constrain the age to a millennial time frame.

Other age-limiting phenomena exist, such as Mercury's youthful surface (Fix, 1999, pp. 202-203), Io's magnetic field decay (Sarson et al., 1997, p. 1106), and Neptune's moon Triton's youthful surface (Naeye, 2000, p. 32).

Abell, G., D. Morrison, and S. Wolff. 1987. *Exploration of the universe*. Saunders, Philadelphia.

Alavi, A., M. Parrinello, and D. Frenkel. 1995. Ab initio calculation of the sound velocity of dense hydrogen. *Science*. 269:1252-1254.

Alexander, A. 1962. *The planet Saturn*. Faber and Faber, London. Reprinted 1980. Dover, New York.

Alfven, H. 1968. On the structure of the Saturnian rings. *Icarus*. 8:75-81.

Anonymous. 1980. The mystery of Venus' internal heat. *New Scientist*. 88:437.

Anonymous. 1999. Cozy nights. *New Scientist*. 162:27.

Anonymous. 2000a. Diamond hail in Uranus and Neptune. *Sky and Telescope*. 99(4):24-25.

Anonymous. 2000b. Lunar surface change: a false alarm. *Sky and Telescope*. 99(3):22.

Asphaug, E. 2000. The small planets. *Scientific. American*. 282(5):46-55.

Baker, R. 1950. *Astronomy*. Van Nostrand, New York.

Baldwin, R. 1965. *A fundamental survey of the moon*. McGraw-Hill, New York.

Barnes, T. 1965. *Foundations of electricity and magnetism*. Heath, New York. Reprinted 1975. T. Barnes, El Paso, TX.

Barnes, T. 1971. Decay of the earth's magnetic field and the geochronological implications. *Creation Research Society Quarterly*. 8(1):24-29.

Barnes, T. 1983. *The origin and destiny of earth's magnetic field*. Institute for Creation Research, El Cajon, CA.

Baum, R. 1954. On the observation of the reported dusky ring outside the bright rings of the planet Saturn. *Journal of the British Astronomical Association.* 64:192-196.

Beatty, J. 1994. "Secret" impacts revealed. *Sky and Telescope*. 87(2):26-27.

Binzel, R., and T. van Flandern. 1979. Minor planets. *Science*. 203:903-905.

Bishop, E., and W. de Marcus. 1970. Thermal histories of Jupiter models. *Icarus*. 12:317-330.

Bloxham, J., and D. Gubbins. 1989. The evolution of the earth's magnetic field. *Scientific American*. 261(12):68-75.

Brush, S. 1983. Ghosts from the nineteenth century: creationist arguments for a young earth. In L. Godfrey, ed. *Scientists confront creationism*. Norton, New York, pp. 49-84.

Brush, S., C. Everett, and E. Garber. 1983. *Maxwell on Saturn's Rings*. MIT, Cambridge, MA.

Burns, J., D. Hamilton, and M. Showalter. 2002. Bejeweled worlds. *Scientific American*. 286(2):64-73.

Carrigan, C., and D. Gubbins. 1979. The source of the earth's magnetic field. *Scientific American*. 240(2):118-130.

Chapman, C., and D. Davis. 1975. Asteroidal collisional evolution. *Science*. 190:553-556.

Chesley, S., S. Ostro, D. Vokrouhlicky, D. Capek, J. Giorgini, M. Nolan, J.-L. Margot, A. Hine, L. Benner, and A. Chamberlin. 2003. Direct detection of the Yarkovsky effect by radar ranging to asteroid 6489 Golevka. *Science*. 302:1739-1742.

Coe, R., and M. Prevot. 1989. Evidence suggesting extremely rapid field variation during a geomagnetic reversal. *Earth and Planetary Science Letters.* 92:292-298.

Coe, R., M. Prevot, and P. Camps. 1995. New evidence for extraordinarily rapid change of the geomagnetic field during a reversal. *Nature*. 374:687-692.

Corliss, W., ed. 1979. *Mysterious universe*. Sourcebook Project, Glenn Arm, MD.

Cuzzi, J. 1985. Ringed planets - still mysterious II. *Sky and Telescpe*. 69(1):19-23.

Dalrymple, G. 1991. *The age of the earth*. Stanford University, Stanford, CA.

Darwin, G. 1898. *The tides*. Houghton Mifflin, Boston.

DeYoung, D. 1990. The earth-moon system. In R. Walsh, editor. *Proceedings of the Second International Conference on Creationism*. Creation Science Fellowship, Pittsburgh. 2:79-84.

Dupuis, N. 1910. *The elements of astronomy*. Uglow and Co. Cited in H. Armstrong. 1976. Possible evidence that Saturn's rings are young. *Creation Research Society Quarterly*. 13(2):120.

Eberhart, J. 1986a. Saturn's "ring rain." *Science News*. 130(6):84.

Eberhart, J. 1986b. Voyager 2's Uranus: "totally different." *Science News*. 129(5):72-73.

Elliot, J., and R. Kerr. 1984. *Rings: discoveries from Galileo to Voyager*. MIT, Cambridge, MA.

Encyclopeadia Britannica. 2001. Uranus. <http://www.britannica.com/bcom/eb/article/printable/2/0,5722,118802,00.html, Jan.uary 22.

Esposito, L. 1987. The changing shape of planetary rings. *Astronomy*. 15(9):6-17.

Farinella, P., Ch. Froeschle, C. Froeschle, R. Gonczi, G. Hahn, A. Morbidelli, and G. Valsecchi. 1994. Asteroids falling into the sun. *Nature*. 371:314-317.

Feibelman, W. 1967. Concerning the "D" ring of Saturn. *Nature*. 214:793-794.

Finch, D. 1982. The evolution of the earth-moon system. *Moon and planets*. 26:109-114.

Firsoff, V. 1968. *The interior planets*. Oliver and Boyd, London.

Fix, J. 1999. *Astronomy*. WCB/McGraw-Hill, Boston.

Gamow, G. 1965. *A planet called earth*. Bantam, New York.

Gentry, R. 1968. Fossil alpha-recoil analysis of variant radioactive halos. *Science*. 160:1228-1230.

Gentry, R., S. Cristy, J. McLaughlin, and J. McHugh. 1973. Ion microprobe confirmation of Pb isotope ratios and search for isomer precursors in polonium radiohalos. *Nature*. 244:282-283.

Gentry, R. 1992. *Creation's tiny mystery*. Earth Science Associates, Knoxville, TN.

Goldsmith, D. 1985. *The evolving universe*. Benjamin Cummings, Menlo Park, CA.

Grinnell, G. 1976. Catastrophism and uniformity: a probe into the origins of the 1832 gestalt shift in geology. *Kronos*. 1(4):68-76.

Guillot, T. 1999. Interiors of giant planets inside and outside the solar system. *Science*. 286:72-77.

Guillot, T., G. Chabrier, D. Gauthier, and P. Moriel. 1995. Effect of radiative transport on the evolution of Jupiter and Saturn. *Astrophysical Journal*. 450:463-472.

Hammond, A. 1974. Exploring the solar system III: whence the moon. *Science*. 186:911-913.

Hansen, K. 1982. Secular effects of oceanic tidal dissipation on the moon's orbit and the earth's rotation. *Reviews of. Geophysics and Space Physics*. 20:457-480.

Hartmann, W. 1972. *Moons and Planets*. Wadsworth, Belmont, CA.

Hartmann, W. 1991. *Astronomy*. Wadsworth, Belmont, CA.

Henry, J. 2001. The energy balance of Uranus: implications for special creation. *Creation Ex Nihilo Technical Journal*. 15(3):85-91.

Henry, J. 2003. An old age for the earth is the heart of evolution. *Creation Research Society Quarterly*. 40(3):164-172.

Horn, L., M. Showalter, and C. Russell. 1996. Detection and behavior of Pan wakes in Saturn's A ring. *Icarus*. 124:663-676.

Hubbard, W. 1984. *Planetary interiors*. Van Nostrand Reinhold, New York.

Humphreys, D. 1990. Physical mechanism for reversals of the earth's magnetic field during the flood. In R. Walsh, editor. *Proceedings of the Second International Conference on Creationism*, Creation Science Fellowship, Pittsburgh, 2:129-142.

Humphreys, D. 2002. The earth's magnetic field: closing a loophole in the case for its youth. *Creation Matters*. 7(2):1-4.

Humphreys, D. 2004. Mercury's messenger. *Creation Matters*. 9(4):1,9.

Ingersoll, A. 1987. Uranus. *Scientific American*. 256(1):38-45.

Isbell, D., and R. Villard. 1995. Saturn moon mystery continues. <http://nssdc.gsfc.nasa.gov/planetary/text/satrpx1095.txt>, October 5.

Janssen, M., R. Hills, D. Thornton, and W. Welch. 1973. Venus: new microwave measurements show no atmospheric water vapor. *Science*. 179:994.

Jeffreys, H. 1916. On certain possible distributions of meteoric bodies in the solar system. *Monthly Notices of the Royal Astronomical Society*. 77:84-92.

Jeffreys, H. 1920. Transparency of Saturn's rings. *Journal of the British Astronomical Association*. 30:294-295.

Jeffreys, H. 1947. The effects of collisions on Saturn's rings. *Monthly Notices of the Royal Astronomical Society*. 107:263-267.

Johnson, T. 2000. The Galileo mission to Jupiter and its moons. *Scientific American*. 282(2):40-49.

JPL. 2002. Chaos seen in movement of ring-herding moons of Saturn. *Science Daily*. <http://www.sciencedaily.com/ releases/2002/10/021014072923.htm>, October 14.

Kerker, M. 1974. Movement of small particles by light. *American Scientist*. 62(1):92-98.

Kerr, R. 1985. Making better planetary rings. *Science*. 229:1376-1377.

Kerr, R. 1989. The Neptune system in Voyager's afterglow. *Science*. 245:1450-1451.

Kerr, R. 1990. Venus is looking too pristine. *Science*. 250:912.

Kerr, R. 1994a. Geophysicists celebrate two satellites, mourn a third. *Science*. 264:1666-1667.

Kerr, R. 1994b. A new portrait of Venus: thick-skinned and decrepit. *Science*. 263:759-760.

Kerr, R. 2004. Hydrocarbon seas of Titan gone missing. *Science*. 306:1676-1677.

Kerr, R. 2005. Titan, once a world apart, becomes eerily familiar. *Science*. 307:330-331.

King, H. 1955. The history of the telescope. Griffin, London. Repr.inted 1979. Dover, New York.
Kitt, M. 1987. Sculpting the moon. *Astronomy*. 15(2):82-87.
Lang, K. 1992. *Astrophysical data: planets and stars*. Springer-Verlag, Berlin.
Leicester, J. 2005. Methane rain falls hard on Titan's plains, scientists say. *Tampa Tribune.* January. 22, p. 7.
Lewis, T. 1895. The dimensions of Saturn's rings. *Observatory*. 18:379-385.
Lewis, T. 1896. Measures of Saturn's rings. *Observatory*. 19:202-203.
Lissauer, J. 1997. It's not easy to make the moon. *Nature*. 389:327-328.
Lissauer, J., and G. Stewart. 1993. Growth of planets from planetesimals. In E. Levy and J. Lunine, editors. *Protostars and planets III*, University of Arizona, Tuscon, pp. 1061-1088.
Masetti, N., and K. Mukai. 2000. What keeps planetary rings in place? <http: //imagine.gsfc. nasa.gov/docs/ask_astro/answers/981027a.html>, April 15.
Maxwell, J. 1859. *On the stability of the motion of Saturn's rings*. Macmillan, London. In W. Niven, editor. 1890. *The scientific papers of James Clerk Maxwell*. Cambridge University, London. 2:289-374. Reprinted 1965. Dover, New York.
Middlehurst, B., J. Burley, P. Moore, and B. Welther. 1968. *Chronological catalog of reported lunar events*. NASA, Washington, DC.
Middlehurst, B., and P. Moore. 1967. Lunar transient phenomena: topographical distribution. *Science.* 155:449-151.
Morrow, L. 1974. Mercury unveiled. *Time*. 103:52.
Munk, W. and G. MacDonald. 1960. *The rotation of the earth*. Cambridge University, London.
Murray, B. 1975. Mercury. *Scientific American*. 233(9):59-68.
Naeye, R. 2000. Neptune's Triton a mere babe. *Astronomy*. 28(3):33.
Napier, W., and V. Clube. 1979. A theory of\ terrestrial catastrophism. *Nature*. 282:455-459.
NASA. 1997. Ring node glossary. <http:// ringmaster.arc.nasa.gov/glossary.html>, February 27.
NASA. 2000. Do Saturn's rings change? <http:// learn.jpl.nasa.gov/projectspacef/bkg450b.html>, April 15.
Nellis, W. 2000. Making metallic hydrogen. *Scientific American*. 282(5):84-90.
Nellis, W., M. Ross, and N. Holmes. 1995. Temperature measurements of shock-compressed liquid hydrogen: implications for the interior of Jupiter. *Science*. 269:1249-1252.
Normille, D. 1999. Experiment uses nuclear plants to understand neutrinos. *Science*. 284:1909-1911.
Northrup, T., and J. Connerney. 1987. A micrometeorite erosion model and the age of Saturn's rings. *Icarus*. 70:124-137.
Ouyed, R., W. Fundamenski, G. Cripps, and P. Sutherland. 1998. D-D fusion in the interior of Jupiter? *Astrophysical Journal*. 501:367-374.
Ouyed, R. 2001. Personal communication. May 18.
Owen, T. 1982. Titan. *Scientific American*. 266(2):98-109.
Pasachoff, J. 1985. *Contemporary astronomy*. Saunders, Philadelphia
Pearl, J., and B. Conrath. 1991. The albedo, effective temperature, and energy balance of Neptune, as determined from Voyager data. *Journal of Geophysical. Research*. 96(supplement):18921-18930.
Pearl, J., B. Conrath, R. Hanel, J. Pirraglia, and A. Coustenis. 1990. The albedo, effective temperature, and energy balance of Uranus, as determined from Voyager IRIS data. *Icarus*. 84:12-28.
Perth Observatory. 2001. Uranus. <http://www.wa .gov.au/perthobs/hpc2ura.htm>, January.. 22.
Podolak, M., W. Hubbard, and J. Pollack. 1993. Gaseous accretion and the formation of giant planets. In E. Levy and J. Lunine, editors. *Protostars and planets III*, University of .Arizona, Tuscon, pp. 1109-1148.
Pollack, J., and J. Cuzzi. 1981. Rings in the solar system. *Scientific American*. 245(5):104-129.
Rasool, S., and C. de Bergh. 1970. The runaway greenhouse effect and accumulation of CO_2 in the Venus atmosphere. *Nature*. 226:1037-1039.
Robbins, R., and W. Jeffreys. 1988. *Discovering astronomy*. Wiley, New York.
Rubin, A. 2002. Exploring Saturn's rings. *Astronomy*. 30(12):49-53.
Ruzicka, A., G. Snyder, and L. Taylor. 1998. Giant impact and fission hypotheses for the origin of the moon. *International Geolology Review*. 40:851-864.
Sagan, C. 1960. The surface temperature of Venus. *Astrophysical Journal*. 65:352-353.
Samec, R. 2000. *The age of the Jovian planets*. *Creation Ex Nihilo Technical Journal*. 14(1):3-4
Sarson, G., C. Jones, K. Zhang, and G. Schubert. 1997. Magnetoconvection dynamos and magnetic fields of Io and Ganymede. *Science*. 276:1106-1108.
Saumon, D., W. Hubbard, G. Chabrier, and H. van Horn. 1992. The role of the molecular-metallic transition of hydrogen in the evolution of Jupiter, Saturn, and brown dwarfs. *Astrophysical Journal*. 391:827-831.
Seife, C. 1999. Moon mystery emerges from the X-Files. *New Scientist*. 163:22.
Sheehan, W., and T. Dobbins. 1999. The TLP myth: a brief for the prosecution. *Sky and Telescope*. 98(3):118-123.
Short, N. 1975. *Planetary geology*. Prentice-Hall, Englewood Cliffs, NJ.
Showalter, M. 1992. A survey of the narrow planetary rings. *Eos*. 73 (supplement):177. <http://ringside.arc.nasa.gov/www/showalter /1992_montreal.html>
Showman, A., and R. Malhotra. 1999. The Galilean satellites. *Science*. 286:77-84.
Slusher, H. 1980. *Age of the cosmos*. Institute for Creation Research, El Cajon, CA.
Snow, T. 1984. *Essentials of the dynamic universe*. West, St. Paul.
Sobel, D. 1994. Secrets of the rings. *Discover*. 15(4):86-91.
Soderblom, L. 1980. The Galilean moons of Jupiter. *Scientific American*. 242(1):88-100.
Soderblom, L., and T. Johnson. 1982. The moons of Saturn. *Scientific American*. 244(1):101-116.
Spencer, J., L. Tamppari, T. Martin, and L. Travis. 1999. Temperatures on Europa from Galileo photopolarimeter-radiometer. *Science*. 284:1514-1516.
Struve, O. 1883. Neue Messungen an den Saturnsringen. *Astronomische Nachrichten.* 105:17-20.
Struve, O. 1960. Planets with rings. *Sky and Telescope*. 20(1):20-23.
Talcott, R. 2000. Leonid meteors strike the moon. *Astron*.omy 28(3):28, 30.
Taylor, W. 1883. Rings of Saturn. *Science*. 2:660.
Tedesco, E. 1979. Binary asteroids: evidence for their existence from lightcurves. *Science*. 203:905-907.
Thompson, W. 1976. Catastrophic origins for the asteroids and the rings of Saturn. *Creation Research Society Quarterly*. 13(2):84.
Tippets, M. 1979. Voyager scientists on dilemma's horns. *Creation Research Society Quarterly*. 16(3):185.
Trefil, J. 1985. *Space time infinity*. Pantheon/ Smithsonian, New York.
Trulsen, J. 1972. On the rings of Saturn. *Astrophysics and Space Science*. 17:330-337.
Urey, H. 1971. Was the moon originally cold? *Science*. 172:403-405.
Verhoogen, J. 1980. *Energetics of the earth*. National Academy of Sciences, Washington, DC.
Veverka, J., P. Thomas, D. Simonelli, M. Belton, M. Carr, C. Chapman, M. Davies, R. Greeley, R. Greenberg, J. Head, K. Klassen, T. Johnson, D. Morrison, and G. Neukum. 1994. Discovery of grooves on Gaspra. *Icarus*. 107:72-83.
Vickers, B. 1998. Some questionable creationist credentials. <http://talkorigins.org/faqs/credentials .html>, June 24.
Whitcomb, J., and D. DeYoung. 1978. *The moon: its creation, form, and significance*. BMH Books, Winona Lake, IN.
Williams, D. 1997. Saturn ring plane crossing. <http:// nssdc.gsfc.nasa.gov/planetary/satmoons _pr.html>, June 20.
Williams, D. 1999a. Jovian satellite fact sheet. <http://nssdc.gsfc.nasa .gov/planetary/factsheet /joviansatfact.html>, December 7.
Williams, D. 1999b. Saturnian rings fact sheet. <http://nssdc.gsfc.nasa.gov/planetary/factsheet /satringfact.html>, March 10.
Williams, D. 1999c. Saturnian satellite fact sheet. <http://nssdc.gsfc.nasa.gov/planetary/factsheet /saturniansatfact.html>, November 8.
Williams, D. 2000a. Asteroid fact sheet. <http:// nssdc.gsfc.nasa.gov/planetary/factsheet /asteroidfact.html>, April 27.
Williams, D. 2000b. Moon fact sheet. <http://nssdc .gsfc.nasa.gov/planetary/factsheet/moonfact .html>, January 27.