Was the Year Once 360 Days Long?

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Abstract

Many recent creationists believe that the year originally was 360 days long. I examine the biblical and ancient nonbiblical arguments for this and find them wanting. Suggestions that the year was originally 360 days lack physical rigor of a mechanism to alter the year to its current length, and so it is difficult to criticize them physically in the general case. However, I propose here a very simple model of how part of this might have happened, and I show that the energy involved is unrealistically high. It is doubtful that a successful physical model that could have changed the year from 360 days to 365 days can be produced.

Introduction

There is a belief among many recent creationists that the year once had 360 days and that the month was 30 days long. This is quite different from the year as it now exists (365.24 days) and the current length of the month (29.531 days). The reasons for this belief, the time at which the bases for calendars allegedly changed, and the manner in which they changed have many variations. We will examine some of these and evaluate whether any are likely to be true.

Definitions

First, we ought to define what we mean by the year, the month, and the day. The year is the revolution period of the earth around the sun. However, we must specify with respect to what we are measuring the orbital period of the earth. The *sidereal* year is the orbital period of the earth with respect to the stars. That is, if the earth, the sun, and a distant star align with one another, we say that one sidereal year has elapsed when the three align once again. The word "sidereal" means "star." The sidereal year is the true orbital period of the earth, for the stars are so distant as to represent a good nonmoving standard of measurement. The *tropical* year is the revolution period of the earth with respect to the vernal equinox. The equinoxes are the intersections of the ecliptic (the earth's orbital plane) and the celestial equator (an imaginary circle in the sky lying directly above the earth's equator). The ecliptic and celestial equator intersect, making an angle of 23.5 degrees, the angle of the earth's axial tilt. Because both the ecliptic and celestial equator are great circle arcs, they intersect in two places, and hence there are two equinoxes. The equinox where the sun crosses the celestial equator traveling northward is the vernal equinox; the equinox where the sun crosses moving southward is the autumnal equinox.

Why are the sidereal and tropical years not the same length? The spinning earth has a slight equatorial bulge. The gravity of the sun and other objects in the solar system produce a torque on this bulge. This torque results in a gradual shift in the orientation of the earth's rotation axis, an effect that we call *precession*. Precession is easy to demonstrate with a spinning top or gyroscope. The ecliptic is reasonably fixed, but the celestial equator is perpendicular to the rotation axis of the earth and hence must precess as the rotation axis precesses. Thus, the intersections of the celestial equator and the ecliptic, the equinoxes, gradually shift along the ecliptic. In fact, astronomers call this the precession of the equinoxes. It takes 25,900 years to complete

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one precession cycle. Since the vernal equinox slides very gradually along the ecliptic or against the background stars, the tropical year and the sidereal year cannot have the same length.

Which year is the basis of our calendar? The sidereal year is the true orbital period of the earth, but the seasons repeat with the tropical year. Until recently, virtually all societies were agrarian and hence were directly dependent upon agriculture. Even today, we must eat, so we are still dependent upon agriculture, albeit less directly. Knowing when to plant crops is essential knowledge in farming, and so the tropical year is the basis of our calendar. This keeps the seasons synchronized to our calendar, which even most modern people find agreeable.

We can mention at least one other year, the *anomalistic* year. The anomalistic year is the revolution period of the earth with respect to perihelion. Perihelion is the point on a planet's orbit that is closest to the sun. The gravitational perturbations of the other planets cause the earth's perihelion to gradually shift along the ecliptic as well, an effect we call *perihelion precession*. For most purposes, the anomalistic year is not nearly as important as the other two years.

The month is the orbital period of the moon, but as with the year, we must define the month with respect to some reference. The *sidereal* month is the orbital period of the moon with respect to the stars. Since the stars represent a distant, reasonably fixed reference, the sidereal month is the true orbital period of the moon. However, the *synodic* month is the more obvious orbital period of the moon. The synodic month is the orbital period of the moon with respect to the sun. Since the geometrical relationship between the moon, the sun, and the earth determines lunar phases, the synodic month is the period with which lunar phases go through a complete cycle. There are other ways of defining the month, such as the *nodal* month. The nodal month is the orbital period of the moon with respect to its nodes, the nodes being the intersection of the moon's orbit and the ecliptic. The nodal month is important in predicting eclipses, but it is the synodic month that is normally the month of choice for calendar purposes.

Most ancient calendars were observationally based. For example, in the Hebrew calendar, which is still observed today, a month begins when one can spot the first thin crescent moon in the western sky following a new moon. Since this is done shortly after sunset and the Hebrews reckoned the beginning of the day from sunset, this observation quickly determined whether a particular day that just started was the first of a new month or the final day of the previous month. The moon generally is not visible for two to three days near new moon.

Since the synodic month is approximately 29½ days in length, if the beginning of each month (and likewise the end of the preceding month) is observationally determined in this way, the months generally will alternate between 29 and 30 days. With a few years of records, one quickly learns when to anticipate when the first thin crescent is likely to be visible, and thus one can calculate with some certainty in advance (or in the past) when a month is likely to begin. A strictly lunar calendar such as this will result in 12 months and be about 10 days shorter than the tropical year. The Islamic calendar is of this type, so the months of that calendar slip 10 days earlier each year. This is why the Islamic holy month of Ramadan occurs progressively earlier each year, and so that month of religious observance is not fixed with respect to the seasons.

After 12 synodic months, there will be a discrepancy of about 10 days from the tropical year. After another 12 months the discrepancy will be 20 days, and after a third 12-month period the discrepancy will be approximately 30 days. Since this accumulated error is about one month every three years, most ancient lunar calendars corrected for this problem by inserting an intercalary month approximately every third year. The intercalary month is placed at the end of the year. For many ancient calendars, the end/beginning of the year was near the time of the equinoxes. Thus, a year with an intercalary month was approximately 385 days long, and years without an intercalary month were approximately 355 days long. Instead of methodically inserting an intercalary month every third year, many ancient calendars followed the pattern of the Metonic cycle, discovered by Meton of Athens, a fifth-century BC mathematician and astronomer. The Metonic cycle inserts an intercalary month in years 3, 6, 8, 11, 14, 17, and 19 of a 19-year cycle. The ancient Babylonian and Jewish calendars follow this method. We do not know when the Jews adopted this approach, but many think that it may have happened during the Babylonian captivity. There are no direct biblical references to how this was done in Old Testament times, and the earliest specific mentions from secular Jewish literature are medieval.

The Romans took a different approach. The length and frequency of the intercalary month was much more confusing and subject to bureaucratic tampering. The Roman calendar was a strictly lunar-based one until 45 BC, when the Julian calendar reform took effect. The most significant change of the Julian calendar reform was that ten extra days were distributed throughout the twelve months that then existed in the calendar, thus removing the need for an intercalary month and increasing the length of the year to 365 days. This meant that the phases of the moon now drifted progressively earlier in each succeeding month, thus abandoning the strictly lunar basis of the month.

The second most important change of the Julian calendar reform was the institution of observing leap days. Since the tropical year is approximately 365¼ days, an extra day inserted at the traditional place of the intercalary month brought the calendar year in near alignment with the tropical year. The intercalary month had been placed between February and March, so this is where a leap day was inserted every fourth year, and eventually people came to associate this extra day as part of February. Most readers will recognize the elements of this calendar in our own calendar. Some readers probably are aware that the tropical year is actually less than 365.25 days, which results in an error of ¾ day per century. Some of the Christian religious calendar was adopted at the Council of Nicaea in AD 325. The error in the Julian calendar accumulated to ten days between then and the sixteenth century, which necessitated the Gregorian calendar reform in 1582. The Gregorian calendar essentially is the calendar that we observe today.

To bring the calendar back to the standards of AD 325, the Gregorian calendar reform deleted ten days from the calendar—October 4, 1582, was immediately followed by October 15. The more lasting legacy of the Gregorian calendar reform was the altering of the rule for adding leap days. Under the Julian calendar, any year divisible by four is a leap year, but even century years (divisible by 100) are not leap years (common years), unless they are also divisible by 400. This omits three days per four centuries, which amounts to the ¾ day discrepancy for the Julian calendar. Thus, while the years 1700, 1800, and 1900 were leap years, 1600 and 2000 were not.

We should emphasize that there are many other ways that one could reconcile what appears to be a mismatch between the lengths of the days, months, and years, and different ancient societies used different methods. It is important to realize that there is not a single, uniquely satisfying way to do this, or else there would not be such diversity. As with any other measurement system, we get very comfortable with what we are used to, and think other measurements are odd or downright weird. For instance, many moderns find the Hebrew calendar odd with the dates of Passover, Yom Kippur, and other festival and holy days moving about our calendar. However, on the Jewish calendar, those observances are on the same dates each year. For instance, Passover is on the fifteenth day of the first month of the religious calendar. The fifteenth day of any strictly lunar month will be the full moon, and the first month is the month that follows the vernal equinox. The Jewish New Year (on the civil calendar) is the first day of the seventh month of the religious calendar, which occurs about the time of the autumnal equinox. Jewish tradition holds that the creation was at this time, so this is a logical choice for the beginning of the year. The religious calendar was introduced at Sinai as a memorial to the first Passover. The Jewish civil calendar almost certainly predates the religious calendar. Anyone who is used to a lunar calendar would find it odd that our celebrations do not occur on the same phase of the moon during the respective month each year. In other words, our fixed dates bounce about on a lunar calendar.

The day is defined as the rotation period of the earth, but as with the year and month, we must specify the reference frame. The most obvious references are the sun and the stars. The *solar day* is the rotation period of the earth with respect to the sun, and that is the day that we normally use. The *sidereal day*, the rotation period of the earth with respect to the stars, is the true rotation period of the earth. The sidereal day is about four minutes shorter than the solar day. The extra four minutes is made up by the motion of the earth around the sun over the course of a day. The result is that stars rise about four minutes earlier each (solar) day.

Reasons for Belief in a 360-day Year

We are finally prepared to discuss why so many recent creationists think that the tropical year once consisted of twelve 30-day months, or 360 days. Some are motivated by what appears to them to be a cumbersome mismatch between the lengths of the day, month, and year. To them, this appears to violate the description of the original creation as "very good" in Genesis 1:31. However, are these people reading into that passage what their opinion of "very good" is? While the current arrangement may offend some of our mathematical sensibilities, is it not a bit presumptuous to dogmatically assert that the current relationship between our timekeepers is somehow not "very good?" The pronouncement of the creation being "very good" stands in stark contrast to the ravages of sin that soon entered the world. That being the case, to be consistent, one ought to postulate that the mismatch in timekeepers must have happened at the Fall, not at some later catastrophe. Yet, proponents of the 30-day-month and 360-day-year theory generally do not make this case.

Another motivation is that many see the prophetic year of 360 days in the book of Daniel as problematic. If this year does not properly match the actual year, then how could this scheme work? We can answer this in a number of ways. First, most recent creationists who take Daniel as evidence that the year once was exactly 360 days long think that the change happened centuries before Daniel, most notably at the time of the Flood or shortly after. Daniel prophesied in the sixth century BC. Taking the very conservative Ussher chronology, the Flood was in the twenty-third century BC. Thus, if Daniel's use of a 360-day calendar was the result of the year actually being that long, one must question why Daniel used a calendar that was more than a millennium and a half out of date in his time. No one in Daniel's time was observing such a calendar, and no one would have found such a calendar particularly useful. Indeed, there is a much easier answer. We have already discussed how many ancient cultures approximated the length of the year in different ways. The point is, 360 is a very nice, round number, so it works very well in estimating time. Even today some interest calculations are figured on a 360-day basis, but no one in the business sector thinks that the year actually is 360 days long. For instance, users of Microsoft Office should examine the Excel function DAYS360.

Measurement in 360 increments has certain advantages over base ten measurements, such as the number of divisors. Ten is divisible by 2 and 5, but 360 not only is divisible by 2 and 5 but is also divisible by 3 and 4. As a strictly lunar calendar seems peculiar to us with our non-lunar calendar, so measurements in any other base than ten seems odd to us. There is nothing natural or obvious as to why we use base-ten mathematics. Most historians of math believe that we do so because we have ten digits on our hands (and toes!). Long division and multiplication are very cumbersome, but they are required with base-ten arithmetic. For the most part, this chore has been eliminated today with such widespread use of electronic calculators. But until very recently, many computations were done with fractions, and this is where divisors are very helpful. Especially in science we are caught up with the supposed superiority of base ten with the metric system, but for certain conversions, particularly small conversions, fractions work better. Consider the common English standards of volume measurement. There are two cups in a pint, two pints in a quart, four quarts to a gallon, two gallons to a peck, and four pecks to a bushel. One can quickly see that there are 128 cups in a bushel (incidentally, this is base 2). Going the other direction, there is some base three (or alternately, base six) involved. A quarter cup contains four tablespoons, and there are three teaspoons in a tablespoon. Thus, one can quickly see that there are 48 teaspoons in a cup. Many younger people have difficulty with this, for they have never been forced to use fractions in this way. But older people, particularly ones with much experience in cooking and baking, find that they can increase or decrease these measurements very easily to alter the size of a recipe. In similar fashion, people in pre-calculator times found it easier to work in bases other than ten. For instance, the UK monetary system was not decimal until 1971. Prior to that, it took 12 pence to make a shilling, and 20 shillings to make a pound sterling. There were three and six pence pieces (making up ¼ and ½ shilling). Many people today, particularly in the US, find this confusing in making change, but the British got by quite well for centuries with this system.

The ancient Babylonians had a base-60 number system (technically, it was a mingled base six and base 10). The Babylonians apparently introduced the division of the circle into 360 degrees. This is important for several reasons. First, since their number system was already base 60, it required only multiplication by six to get to this figure. Second, the ancient Babylonians attached religious significance to the number six, though it is not entirely clear that this came first or after the adoption of the use of the number six so much. As an aside, the number of the beast, 666, appears to have a direct relation to the city of Babylon in the book of Revelation. Third, the number 360 is very close to the number of days in a year, so at least over the short run, 360 days is a good approximation for the number of days in a year. Keep in mind that Daniel prophesized in Babylon, at the height of Babylonian power and influence. Within this culture, his readers would have understood this simplification without insisting that the year either was or had been exactly 360 days long.

Another biblical passage cited by proponents of the 360-day year is the Flood account. Genesis 7:11 records that the Flood began on the seventeenth day of the second month of the six hundredth year of Noah's life. Of course, nearly everyone is familiar with rain for 40 days and nights (Gen. 7:12). Most recent creationists also are familiar with the statements in Genesis 7:24 and 8:3 that the water prevailed upon the earth for 150 days. That latter statement is followed by Genesis 8:4, which tells us that the ark rested on the mountains of Ararat on the seventeenth day of the seventh month. Assuming that this follows the chronology begun by Genesis 7:11 and that the statements of Genesis 8:3 and 8:4 refer to the same thing, many argue that 150 days here must exactly equal five months, implying a 30-day month. But is this the only possible meaning? No, there are at least three other possibilities.

First, there are a few assumptions listed in the previous paragraph. Those assumptions appear to be sound, but they are assumptions and thus ought to be clearly acknowledged. For instance, the text does not require that verses 3 and 4 of chapter 8 refer to the same events. That is, we cannot necessarily conclude that the end of the prevailing of the waters coincided exactly with the same day that the ark rested upon the mountains of Ararat. Second, there are several possible ways to understand this Genesis 8:4 date and the 150 days of Genesis 8:3. One is the aforementioned exact equivalence, with 150 days exactly equal to five months. However, there are other ways to understand this. We do not know what calendar was employed by Noah; all ancient calendars that we truly understand are far later. At the time, Noah may have used an entirely different calendar, one with even a 30-day month, even though that month did not align with the synodic month and had some unknown mechanism to bring the calendar in line with the moon and the year. A third possibility is that the 150 days of Genesis 8:3 may be an approximation for the amount of time elapsed. Even today we approximate the length of the month by 30 days, as evidenced by so many financial and legal obligations stated in terms of 30, 45, 60, 90, and 180 days. Why are these numbers so often selected as opposed to, say, 10, 20, 50, or 100 days? Obviously, these are approximations to 1, 1½, 2, 3, and 6 months. In our overly litigious society today, the exact day count likely is to take precedence over an integral month count in tort matters, but the number of months undoubtedly is the intention. We do not know how many, if any, attorneys existed at the time of the Flood, but throughout history, an approximation of 30 days has been applied to the month, particularly when the number of months is low. In short, Genesis 8:4 contains a much more precise statement of time measurement than Genesis 8:3 does. That is, the length of time involved is five months (to the day), an interval of approximately 150 days. This conclusion is consistent with the precision of the statements, does no harm to a straightforward reading of Scripture, and does not require that the original month was exactly 30 days long.

Many recent creationists who support the 360 day year claim refer to Emmanuel Velikovsky's *Worlds in Collision* (1950), where Velikovsky claimed that many ancient cultures once had a 360-day year but were forced to add an extra five days at some point because of some abrupt change in the length of the tropical year. For instance, Velikovsky (1950, p. 336) states:

> The Egyptian year was composed of 360 days before it became 365 by the addition of five days. The calendar of the Ebers Papyrus, a document of the New Kingdom, has a year of twelve months of thirty days each. In the ninth year of King Ptolemy Euergetes, or -238, a reform party among the Egyptian priests met at Canopus and drew up a decree; in 1866 it was discovered at Tanis in the Delta, inscribed on a tablet. The purpose of the decree was to harmonize the calendar with the seasons "according to the present arrangement of the world," as the text states. One day was ordered to be added every four years to the "three hundred and sixty days, and to the five days which were afterwards ordered to be added." The authors of the decree did not specify the particular date which the five days were added to the 360 days, but they say clearly that such a reform was instituted on some date after the period when the year was only 360 days long.

Velikovsky apparently chose to interpret this addition of five days as the result of some actual change in the length of the calendar at that time, but that was not the case. Sharpe (1870) translated the tablet that Velikovsky mentioned. Sharpe (1870) provides a translation of this passage in context.

> So that the seasons also may do what is fit in every way according to the present arrangement of the world, and that it may not happen that some of the national festivals, which are held in the winter, should be sometimes held in the summer, in consequence of the star moving one day in four years, and that others of those now held in the summer, should be held in the winter in the future seasons, as had formerly happened to come to pass, from the arrangement of the natural year remaining of three hundred and sixty days and of the five days which were afterwards ordered to be added; from the first day the festival of the gods Euergetae being now carried forward, because of the four years, on to the five days added on before the new civil year; so that all men may know how the former defect in the arrangement of the seasons, and of the natural year, and of the decrees about the whole disposition of the pole, happened to be amended and made perfect by the gods Euergetae (Sharpe, 1870, pp. 15–16).

Notice that the purpose of the decree is to implement the practice of leap year, not to add five days to the 360-day year, for that was already being done. Velikosvky claimed that this marked the institution of adding five days upon the 360-day year, but he could do this only by quoting out of context and emphasizing what was not the purpose of the decree. Consider editorial comments of Sharpe, who translated this stele.

> This Decree is valuable to us for other reasons besides its help to the study of hieroglyphics. It tells us of a proposal then made by the priests to reform the Egyptian calendar, at least, so far as it was used in fixing the days when the religious feasts were to be celebrated. Ever since the year BC 1322, in the reign of Menophra, probably the king better known as Thothmosis II, the Egyptian civil year had consisted of 365 days; and hence, for want of a leap-year, the new-year's day, and the feasts then celebrated, were always moving one day earlier every four years. This change, which must in every generation have been noticed, had now, by the help of the Alexandrian astronomers, been determined with greater exactness. The new-year's day, the 1st of Thoth, which ought to fall on the 18th of July, when the Dog Star is seen to rise heliacally, had now, in the ninth year of Ptolemy Euergetes, moved nearly nine months earlier and fell on the 22nd of October. This is well known from several observations recorded by the Alexandrian astronomers; and quite agrees—at least, as well as observations which depend upon eyesight and the weather can be expected to agree—with the information contained in this Decree, namely, that the Dog Star then rose heliacally on the 1st of Payni. Calculating back

> from what we are told by Censorinus, our great authority on the Calendar, we should have supposed that was not the case till the next year, the 10th of Euergetes. The very small disagreement shows with what accuracy the heliacal rising of the star could be observed. However, the priests proposed to be no longer guided by this movable civil year in the arrangement of their feast days. How far their proposal was acted on we do not know. The change was not made by civil authority till the reign of Augustus, who first introduced the Julian mode of reckoning into Alexandria, in the year BC 25 (Sharpe, 1870, pp. vii–viii).

Thus, Velikovsky takes a very different meaning from the text than that taken by the translator of the text. Using this approach, one could just as well claim that Julius Caesar's addition of leap year was required by some change in the actual length of the year during his lifetime or that the 1582 Gregorian calendar reform was necessitated by change that then occurred. Instead, both of these calendar reforms, along with the one that Velikovsky references, were required by earlier calendars that had failed to properly account for the true length of the tropical year.

Velikovsky continues:

> In the fifth century Herodotus wrote: "The Egyptians, reckoning thirty days to each of the twelve months, add five days in every year over and above the number, and so the completed circle of seasons is made to agree with the calendar" (Velikovsky, 1950, pp. 336–337).

Here Velikovsky quotes from the 1920 translation of Herodotus by A. D. Godley. The complete Herodotus passage earlier translated by Rawlinson (1858) read as follows, with the passage quoted by Velikovsky in italics.

> The Egyptians, they said, were the first to discover the solar year, and to portion out its course into twelve parts. They obtained this knowledge from the stars. (To my mind they contrive their year much more cleverly than the Greeks, for these last every other year intercalate a whole month, but *the Egyptians, dividing the year into twelve months of thirty days each, add every year a space of five days besides, whereby the circuit of the seasons is made to return with uniformity*.)

Note that the quote in context places a different spin on the passage. What Herodotus is commenting on is the manner in which the Egyptians handled the fact that the year is not an integral multiple of the month, and Herodotus found the Egyptian solution to the problem preferable to that of the Greeks. Herodotus in no way stated that the Egyptians had to update their previously accurate calendar of twelve 30-day months because of some disjointed shift in the length of the year, as Velikovsky suggests.

In *The Natural History of Pliny* xxxiv 12 (Bostock and Rily, 1957, p. 159) we read:

> I find also, that statues were erected in honour of Pythagoras and of Alcibiades, in the corners of the Comitium; in obedience to the command of the Pythian Apollo, who, in the Samnite War, had directed that statues of the bravest and the wisest of the Greeks should be erected in some conspicuous spot: and here they remained until Sylla, the Dictator, built the senate-house on the site. It is wonderful that the senate should then have preferred Pythagoras to Socrates, who, in consequence of his wisdom, had been preferred to all other men by the god himself; as, also, that they should have preferred Alcibiades for valour to so many other heroes; or, indeed, any one to Themistocles, who so greatly excelled in both qualities. The reason of the statues being raised on columns, was, that the persons represented might be elevated above other mortals; the same thing being signified by the use of arches, a new invention which had its origin among the Greeks. I am of opinion that there is no one to whom more statues were erected than to Demetrius Phalereus at Athens: for there were three hundred and sixty erected in his honour, there being reckoned at that period no more days in the year: these, however, were soon broken to pieces. The different tribes erected statues, in all the quarters of Rome, in honour of Marius Gratidianus, as already stated; but they were all thrown down by Sylla, when he entered Rome (Bostock and Riley, 1857, p. 159).

Note that Pliny does not state that the year was 360 days long, but that there being was "reckoned at that period no more days in the year."

As for the Persians, Velikovsky (1950, p. 333) wrote,

> The ancient Persian year was composed of 360 days or twelve months of thirty days each. In the seventh century five Gatha days were added to the calendar. In the Bundahis, a sacred book of the Persians, the 180 successive appearances of the sun from the winter solstice to the summer solstice and from the summer solstice to the next winter solstice are described in these words: "There are a hundred and eighty apertures [rogin] in the east, and a hundred and eighty in the west ... and the sun, every day, comes in through an aperture, and goes out through an aperture. ... It comes back to Varak, in three hundred and sixty days and five Gatha days." Gatha days are "five supplementary days added to the last of the twelve months of thirty days each, to complete the year; for these days no additional apertures are provided ...." This arrangement seems to indicate that the idea of the apertures is

> older than the rectification of the calendar.

For his first sentence, Velikovsky (1950) had this as footnote and reference:

> "Twelve months … of thirty days each … and the five Gatha-days at the end of the year." The Book of Denkart, in H. S. Hyberg, Texte zum mazdayasnischen Kalender (Uppsala, 1934), p. 9."

Presumably, Velikovsky provided his own translation. Notice that the quote doesn't actually state when or why the practice of adding five extra days each year began. Velikovsky assumes that it was because of a catastrophic change in the lengths of the month and the year, but the text does not say this. The alleged catastrophic change is Velikovsky's hypothesis, but offering this as support is begging the question. Interestingly, elsewhere the Book of Denkard states,

> Be it known that the solar year is of two kinds. Of these (two solar years) one is made up by the addition of days, the other by the addition of hours. The one that is made up by the addition of days consists of twelve months, each month of which is of thirty days. (When to these three hundred and sixty days) the five additional days, required for the course of the sun through the constellations during twelve months, are added the year becomes one of three hundred and sixty-five days. The five days which are over and above (the thirty days) of each month are placed at the end of the last month of the year. These five days are made up by the increase (in time of the solar year over the year of 360 days) and they are fixed after many calculations. According to such calculations these days are named (in the daily prayers recited on the last five days of the year).
>
> Besides the sum-total of three hundred and sixty-five days there are six additional hours (to be taken into consideration). These hours have to be added every year. These additional (six) hours (for every year) make up one day for four years, ten days for forty years, one month for a hundred and twenty years, five months for six hundred years and one year for one thousand, four hundred and forty years. The time of six hours should be kept apart from (i.e. not to be added to) the last days of the year for many years, till (the hours) amount to (a definite period of time).
>
> This additional period (i.e. the intercalary month at the end of every hundred and twenty years) is fixed by calculations. And it (i.e. the intercalary month) is necessary for (the right performance of) Noruz, Mihragan, and other time-honored Jashans. Again the commencement of the year has been fixed by great kings from the first day of the year from the beginning of creation (Sanjana, 1900).

Notice that the entire text in context clearly shows that the Persians knew that the year was 365 days long and that they added the extra five days to bring their twelve 30-day months into conformity with the actual year, as did the Greeks and Egyptians. More important, the last sentence indicates that this calendar had operated since the beginning of creation, thus contradicting Velikovsky's claim that Persian records indicate an initial 360-day year.

As for Velikovsky's use of the Bundahis, his first quote above is from chapter 5 of the Bundahis. The second quote is from a footnote of E. W. West, the translator of the Bundahis into English. Velikovsky has misinterpreted the meaning. Neither the text nor the footnote says that the five extra days were added to fix some drastic change from an earlier 360-day tropical year. In fact, elsewhere in the Bundahis the idea of the original year being 365 days is alluded to. In chapter 25, in dealing with the religious calendar of ancient Persia, we find this:

> On matters of religion it says in revelation thus: "The creatures of the world were created by me complete in three hundred and sixty-five days," that is, the six periods of the Gahambars which are completed in a year (West, 1897).

And:

> Again, the year dependent on the revolving moon is not equal to the computed year on this account, for the moon returns one time in twenty-nine, and one time in thirty days, and there are four hours (zaman) more than such a one of its years; as it says, that every one deceives where they speak about the moon (or month), except when they say that it comes twice in sixty days. Whoever keeps the year by the revolution of the moon mingles summer with winter and winter with summer (West, 1897).

Note that the creation of the animals was said to have been accomplished in 365 days. This makes no sense if the originally created year actually was 360 days. Furthermore, this second quote explicitly states that the moon's orbit is 29.5 days, and the last sentence firmly states that if one keeps a strictly lunar calendar, the seasons will soon be out of cycle. When these statements are taken in total, it is very clear that Velikovsky's claim that the ancient Persians once had a 360-day calendar is not supported by the Bundahis.

This is the manner in which Velikovsky handled all of his support for his contention that the year was once 360 days long and then abruptly changed to 365 days. It is not clear whether Velikovsky merely misunderstood what he was reading or if he intentionally misrepresented the references to support his thesis. At any rate, careful analysis of the supporting references footnoted by Velikovsky reveal that the original sources in no way support the idea that the tropical year was once measured to be 360 days long. Unfortunately, many creationists have uncritically accepted Velikovsky's claims in this matter, and with no actual statements from antiquity concerning the tropical year actually being 360 days in length, the case for this is severely weakened.

Supposed Changes in the Year

When did the length of the year allegedly change? The most common claim is that the year lengthened by five days at the time of the Flood, though some suggest some post-Flood catastrophe such as Babel or a supposed physical dividing of the earth at the time of Peleg. How might such a change in the length of the year have been accomplished? Again, there is much diversity of opinion. The most straightforward change would be in the orbital period of the earth. That is, an impact or some other catastrophe moved the earth farther from the sun and thus increased the orbital period. This is fraught with problems.

First, for an impact to do this, it must be precisely directed. The easiest way requiring the least energy would be an impact in the direction that the earth is orbiting the sun, which would propel the earth forward. Orbital dynamics can be tricky. If an orbiting body is propelled forward in its orbit, the orbit generally is raised (with a corresponding increase in orbital period). If this kick is delivered at perihelion, aphelion is raised, but perihelion remains unchanged. Conversely, if the kick is delivered at aphelion, perihelion is raised while aphelion is unaffected. If the orbital energy is inserted at any other time, then the computation gets more difficult. And if the increase in motion is not in the direction of the earth's motion, then far more energy is required.

As an example, suppose that the original orbit of the earth was circular with the orbital radius equal to the earth's current perihelion distance and that the earth's orbit was changed by raising aphelion and increasing the eccentricity of the orbit. The earth's current perihelion distance is 1.47095×10^{11} m. Taking this as the original circular orbit distance from the sun, the general form of Kepler's third law of planetary motion shows that the original orbital period was about 356 days, roughly four days shorter than desired. As a second approximation, one might suppose that the original orbit was not perfectly circular but less elliptical than today's orbit. An eccentricity about half of today's eccentricity but with the same perihelion distance would produce something close to a 360-day orbital period. A kick delivered at perihelion and directed forward in the earth's motion could produce today's orbit.

As a specific example, let us consider a very simple model for changing the earth's orbit by a directed impact at perihelion so that the length of the year increased from 360 days to the current 365.25 days but the perihelion distance did not change. For the orbital period to be 360 days, the average distance of the earth from the sun would have been 1.481593×10^{11} m. If we match the current perihelion distance of 1.47098 $\times 10^{11}$m, the eccentricity would have been 0.007183, about 43% the current eccentricity, consistent with our estimate above of about half the current eccentricity. We can determine the orbital speed at perihelion of both the original orbit and the current orbit by using the *vis viva* equation,

$$v^2 = G(m+M)[\frac{2}{r} - \frac{1}{a}],$$

where v is the velocity, m is the mass of the earth, M is the mass of the sun, r is radius vector, and a is the semimajor axis of the orbit. Using the values already stated, the original orbital velocity at the perihelion was 3.01396×10^4 m/s, while the orbital velocity at the perihelion after the collision was 3.02821×10^4 m/s. This is a change in speed of 142 m/s. How large would the impacting body likely need to have been? A high velocity for a meteoroid is 5×10^4 m/s. Assuming this initial speed for the impacting body and 142 m/s velocity change, conservation of momentum requires that the impacting body have been 0.28% the mass of the earth, a little more massive than Pluto.

A second difficulty is that the amount of energy involved is quite staggering. The amount of orbital energy difference of this impacting body is $\sim 3 \times 10^{31}$, which amounts to approximately 4 million J for each kg of the earth's mass. This would be an inelastic collision, so only a portion of that energy would go into altering the orbit; the rest would be absorbed by the earth. Even if only a tiny fraction of the energy were absorbed by the earth, a large problem would result. The effects of such an impact are staggering, and this is for a minimum energy impact. For a less ideally oriented and timed impact, the energy released would be far more – an actual impact likely would have been more energetic. Therefore, it does not seem likely that the earth's year could have been increased by changing the earth's orbit.

An alternate way to lengthen the year would be to shorten the day. This could be accomplished either by applying a torque that speeds the earth's rotation or by decreasing the earth's momentum of inertia, perhaps by shrinking the earth in size.

This leaves the difficulty of changing the length of the month. This must happen by decreasing the moon's angular momentum, most likely by injecting energy at the right position, direction, and time to lower the moon's orbit. This is the reverse of the scenario just mentioned about raising the earth's orbit.

Ultimately, one must change both the length of the month and alter the number of days in a year. It is possible to do this several ways, so it is difficult to criticize the exact mechanism that might be employed (until someone actually suggests such a mechanism). If and when such a model is proposed, then it may be possible to assess whether this is a physical possibility that does not require too much energy. However, the brief discussion here shows what a typical energy requirement might be.

Conclusion

I have explored the biblical, extrabiblical, and physical arguments for the thesis that the year once was 360 days long. No Bible passages tell us that the year originally was 360 days long. Rather, people have inferred this from some passages. However, those passages do not demand that the original year was 360 days long, and they easily can be understood in terms of no significant change in the length of the year. Much of the argument for the original year being 360 days comes from nonbiblical ancient sources, but examination of those sources reveal that those passages were misinterpreted by Velikovsky. Lacking in most discussions of an alleged original 360-day year is a specific mechanism for how a large change in the year may have happened. A simple calculation of a possible mechanism shows that the energy required to make such a large change would have been unacceptably large. Proponents of an original 360-day year ought to produce their models of how the change might have happened so that we can assess the energy input. Until such models are produced and examined, recent creationists are cautioned against advocating an original 360-day year.

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