Analysis of a Disagreement: The Month in Science and Torah(*)

By Morris Engelson

My book *The Heavenly Time Machine* is based on the premise that both science and the Bible are true. We would prefer to have no disagreements, of course. But we do not consider disagreements between science and Torah as something to avoid. Rather we look at these as a possible source of new learning and knowledge as we explore means to a common understanding. I would like to demonstrate this process by exploring the implications of a statement that I make in my book. I state that Torah Sages knew the time duration of the month to a very high degree of accuracy. My intent was to show that these people were not ignorant of science, as some would have us believe. Having made this point, I then proceed to other matters. But there is more that can be said here.

Statement of the problem

Quoting from pages 140-141 of my book. “We have a statement on the length of the lunar month on page 25a in Tractate *Rosh Hashanah.* This would be the cycle of the phases of the moon, otherwise known as the synodic month. Rabban Gamliel says that he has it from the traditions of his grandfather’s house that the length of the month is 29 days plus half a day plus two-thirds of an hour plus 73 parts of an hour. An hour is divided into 1080 parts in Talmudic measure. Addition of these numbers yields a lunar month that is 29.530594 days long. Current measurements, as reported in the Encyclopedia Britannica, show a mean time period of 29.530588 days.”

What is the problem? Rabban Gamliel of Yavneh, who made this statement, died in the year 110. His grandfather, Rabban Gamliel the Elder, lived almost two thousand years ago, in the early part of the first century. He claimed a time period for the month that is within half a second of the best result that current science can achieve. We can marvel at such an accurate result. But that does not make for a problem. The problem comes from part of the statement, made by Rabban Gamliel, that I did not quote in my book. The full statement is that the time duration of the month can not be less than 29.530594. But modern science says that the time is, in fact, less. That is the source of the problem.

Resolving the problem

- There is always an uncertainty error in every measurement. Is it possible that the half second difference is within the measurement uncertainty? No, that is not possible for two reasons. One reason is that the best current value is given as 29.5305888531. This is orders of magnitude beyond the number we are using; truncated after 88. This level of error is equivalent to a 10 meter measurement uncertainty when using a centimeter-based ruler. It is impossible. A second possibility is that the theory upon which the measurement is based is flawed. But the measurement is based on Newton’s laws of motion. We would have to scrap pretty much all of physics if Newton’s laws were wrong to this extent. No, the science-based number is rock solid. However I will adjust the number I use in the

rest of this discussion to end at 89, and not 88, as I previously stated. The next value is an 8, hence rounding the previous 8 to a 9, is more appropriate for accurate computations.

- Is it possible that the number determined from the Bible is wrong? No, because we stipulate as part of the logic of the process, that the Bible is true. Nevertheless, it is possible that a statement made by Rabban Gamliel is not correct, providing he did not get his information from the Torah. It is well known that various people, including Rabban Gamliel, made astronomical observations and measurements. Could Rabban Gamliel (or rather his grandfather) have obtained his value by measurement? Secular Bible scholars claim that that is how the result was obtained.

  Here is how it could have been done. We determine, as accurately as possible, the day, date, and time of a conjunction at the time of an eclipse. The information is maintained for hundreds of years, so that we accumulate thousands of lunar months. Let us say that we know the time and date of two conjunctions separated by 3600 months, to an accuracy of 30 minutes. Half an hour yields an error of 1800 seconds. But that is for all of the 3600 months. The average error per month is only 1800/3600 = 0.5 seconds. We no longer have an issue between Torah and science, but rather between modern science and ancient science. My statement that ancient Torah Sages were not ignorant of science still holds, and all is well. But this solution does not work, because Rabban Gamliel was, in fact, dealing with Torah, as discussed next.

- You will recall that Rabban Gamliel gave the time between two new moons as 29 days, plus half a day, plus 2/3 of an hour plus 73 parts of an hour. Half a day is 12 hours, and 2/3 of an hour is 720 parts of an hour, at 1080 parts per hour. The total number of days is 29, individual hours is 12 and the number of remaining parts is 720+73 = 793. Hence it is common in Talmudic discourse to identify the time period of the month as 29-12-793. We have a firm tradition that this number, 29-12-793, was handed down from Moses at Sinai. Not only that, but we hold that formulas for calculating the months, some of which are shorter and some longer, how to determine the Rosh Hashanah (New Year), which may fall on certain days of the week, but not others, and a number of other related matters came to us from Moses. Yes, Rabban Gamliel did make measurements. But the authority for making the statement that he made is based on Torah and not on science. Rabban Gamliel, as you will see later, made the statement as he overruled the central court who were about to announce a new month. It is inconceivable that anybody would do such a thing except on the authority of the Torah.

  I refer to the article, Calendar Configurations, by Rabbi Moishe Kimmelman, on page 85/86 of the April 20, 2001 issue of **Hamodia,** for those interested in a summary explanation respecting the numerous calculations, formulas and numbers that we hold as a tradition from the time of Moses. Rabbi Kimmelman cites the Gaon of Vilna, who notes that the number 793 came before the number 1080. The hour could have been divided simply into 15 portions, of which 11/15

is equal to 792 parts of an hour. Instead we are forced to use the large number, 1080, so as to permit the more precise 793. The number 793 is important not only for measurement accuracy but also, other, more mysterious reasons. Thus, Rabbi Avraham Chaim Carmel points out the following. Multiply 29 days by 24 to get hours. Add the additional 12 hours and multiply by 1080 to get parts of an hour. Finally, add 793 to the result to obtain all the parts of an hour. This yields the descending order 765,432+1. This number has kabalistic implications. But I do not know what it means.

- The next conclusion to this issue is to agree that we have no answer. Not having an answer does not hurt the original premise that both Torah and science are true. There are many things that people do not know. But that does not make them untrue. Fermat's last theorem was shown to be true just a few years ago. But it was just as true for previous centuries when nobody knew the answer, as it is true now that we do know the answer. There are certain things that are beyond our knowledge and we need to let these go into the future. Fortunately, that is not the case respecting the matter of the month.
- We now come to the process that will resolve the puzzle as to how a statement that some value can not be "less than" is just as true as a statement that the value is in fact "less than." The resolution involves a deeper look into what the Torah-based statement is really about. Combined with a more sophisticated science-based analysis, will show that science and Torah are in full agreement. Not only that, but we will uncover in the process some relationships, that we might otherwise miss.

What did Rabban Gamliel say, and what did Rabban Gamliel mean?

I refer to the following sources for what follows:

The primary reference is the Talmud Tractate *Rosh Hashanah*. Rosh Hashanah means the New Year. A new year begins at the beginning of a month. Hence, to understand the timing of Rosh Hashanah, we need to understand the timing of Rosh Chodesh (new month). This explains why the Tractate *Rosh Hashanah* has much information about Rosh Chodesh. Talmud pages have the same number front and back. The front is identified as "a", and the back as "b." *Rosh Hashanah*, 25a refers the reader to the front side of page 25 in Tractate *Rosh Hashanah.*

Another reference is the classic commentary *Bais HaBechirah* authored by 13th century commentator Rabbi Menachem HaMeiri (Meiri). I also refer to Maimonides' discussions respecting the month in *Hilchos Kiddush Hachodesh* (rules respecting the sanctification or announcement of the month). Finally, we have the previously referenced article by Rabbi Kimmelman.

The time of the new month has been determined by calculation for the last 1640 years (since year 359). This was necessitated by the exile and dispersion of the Jews. Calculations could have been done previously, as we hold that formulae come to us in the

oral Torah from Moses. However, the preferred method is for the court to announce the new moon on the basis of testimony from witnesses who saw the new moon. This was the process at the time of Rabban Gamliel, head of the community in the late first century.

We are told (*Rosh Hashanah* 25a) that the sky was overcast, and some people thought they saw the appearance of the new moon in the clouds. They testified before the court, and the court was about to announce the new month. But Rabban Gamliel stopped the process. He explained that the witnesses could not have seen the moon yet, because he had a tradition from his grandfather that the time from one new moon to the next can not be less than, etc. Clearly Rabban Gamliel overruled the testimony of the witnesses on the basis of a calculation. Is that permitted? Yes. We have a discussion on this matter in *Rosh Hashanah*, 20b, where Rav Ashi explains that, "By calculating the conjunction, we are able to refute false witnesses." Indeed, calculation is the only way to know the precise moment of the conjunction, because the moon is not visible at that time.

We know from the foregoing that Rabban Gamliel was interested in a specific practical case. He did not set out to expound on the information that he had from his grandfather. There is more such information that Rabban Gamliel mentions at other times. Meiri explains that Rabban Gamliel simply provided the information needed to refute the testimony of the witnesses. He did not give less, and he also did not give more than needed for his purpose. Meiri tells us that the full tradition is that the time period for the month can not be less than 29-12-793, and it also can not be more than 29-12-793. "Not less than and not more than." Does that mean that the time period is equal to 29-12-793? No it does not. We know today that each month lasts a slightly different time period, and the science-determined value is an average. This was also known from Torah. Rabban Gamliel tells us that he has it from his grandfather, that the period varies and that "sometimes it (the moon) travels by the long route, and sometimes by the short route." Maimonides explains the meaning of "not less than, and not more than." He notes that we use an average value of 29-12-793, and the deviation from this value is sufficiently small that this is the number that we should use.

We now have a much better understanding of the information from the Torah. But it does not eliminate our problem. The fact is that Rabban Gamliel invoked the "not less than" rule. Could he do that when science says that it really is less? Furthermore, we know that it took less time for the moon to go around the Earth two thousand years ago than it does today. If the actual month (this is not any particular month, but rather the average) is less than the Rabban Gamliel number today, then it had to be even less than that in the past. How much less, and can we justify the difference? This calls for a deeper understanding of the science, which comes next.

What is a month?

The solar year is divided into 12 months. These, solar months, are arbitrary constructs. We could divide the year into ten months, or fifteen months, or any other number of months. We just happen to use twelve because of our experience with the moon. The moon moves around the Earth roughly 12 times a year. The elapsed time between two

successive new moons, or other phases of the moon, is one lunation. The lunar month is a time measure of a lunation. These, lunar, months are not arbitrary constructs, because we can measure the time duration of a month by astronomical observation. How the measurement is made will determine what type of (lunar) month we are talking about.

We will ignore the more obscure months, such as the tropical month or nodical month. This leaves two well-known lunar months: the sidereal month and the synodic month. The sidereal month last a bit over 27 days, and is the time of one rotation of the moon as measured against the position of the stars. The synodic month lasts about 29.5 days, and is the time of one rotation of the moon as measured with respect to the sun. The difference between these two type months is accounted for by the movement of the Earth with respect to the stars, as the Earth rotates around the sun. The Torah deals with the synodic month, and that is the subject of our discussion. The current average value of the synodic month, as determined by the exact conjunction of the moon and sun (as observed from the Earth) has been determined to be 29.5305888531 days. I will round this to 29.530589 days to provide the same decimal precision as the number given by Rabban Gamliel, which is 29.530594 days (converted to modern units of measure from 29-12-793). The difference between these two numbers is 0.000005 days, or 0.432 seconds. Currently the month lasts 0.43 seconds less time than noted by Rabban Gamliel. Therein lies our original question, because Rabban Gamliel says the month can not be shorter than this value.

In fact, the situation appears to be even worse than noted above. This is because the movement of the moon takes about 0.18 seconds more per millennium to go around the Earth. Hence it took about 0.4 seconds less time for the moon to go around the Earth 2000 years ago when Rabban Gamliel made his pronouncement. Combining with the current difference, it appears that the month was 0.8 seconds less than the Rabban Gamliel number, two thousand years ago. I say it “appears,” because that is all it is. This is the appearance, but not the actual situation. The discrepancy comes from a timing reference.

We have numerous measures and definitions for the passage of time. Here are a few: atomic time, apparent time, universal time, dynamical time, sidereal time…, and others. The current standard for time measurement, which has been in effect since 1967, is the IAT (international atomic time) second. The IAT second is equal to 9,192,631,770 cycles of the transition between two hyperfine levels of the ground state of cesium 133. This reference second is a fixed number that does not change with the date. The cesium atom behaved the same way 2000 years ago as it does today. When I say 2000 years ago the month was 0.8 seconds less than Rabban Gamliel claimed, I mean 0.8 IAT seconds. But Rabban Gamliel was not talking about IAT seconds, or any other kind of seconds. He was talking about days and fractions of a day. A day is one rotation of the Earth on its axis, and it need not be precisely 86,400 seconds in duration, at 24 hours and 3600 seconds/hour. Here the day is the reference standard, and its atomic time duration is of no consequence. A day is a day. There are 24 hours in one day, whatever time duration that happens to be. There are 1080 parts to each hour. The month, according to Rabban

Gamliel is 29-12-793, and not 29.530594 days consisting of 86,400 seconds each. This brings in an additional factor that we had not previously considered.

The Earth is slowing down its rotation, and the length of the day is increasing at about 2.3 milliseconds per century. Days were shorter 2000 years ago than now. Hence the month lasted more days then, than it does today. We have two opposite effects here. The longer lunation means that the IAT time for the month was shorter in the past. The slowing of the Earth's rotation means that the IAT time for the month was longer in the past. We need to determine the net result of these two effects. The value for the increased lunation time, the slowing of the Earth and formulas for determining the impact of these, is not simple to determine. I am pleased that I was spared any of this fundamental work by a thorough presentation on this topic, Lunar Calendars, written by Peter Myer. The reader will find this reference at URL serendipity.magnet.ch/hermetical/cal_stud/lunarcal/luncal.html. Meyer provides formulas from which the time duration of, what he calls, the IAT synodic month and observed synodic month, can be calculated for any calendar date. We are interested in the observed month, as that is what Rabban Gamliel was talking about. The result is not exactly constant or linear, with change of date. But I am not looking for a very high level of precision. Hence I can use a single number for all that I need to accomplish. Using the formulas provided by this reference, and taking into account both the movement of the moon and rotation of the Earth, I find that the observed month changes at the rate of 0.51 seconds per millennium. The month was 0.51 seconds longer 1000 years ago than it is today.

At this time, the month is 0.43 seconds less than the Rabban Gamliel number. Hence, 2000 years ago, the month was 0.51x2-0.43 = 0.59 seconds longer than the value cited by Rabban Gamliel. Rabban Gamliel was correct when he overruled the witnesses. The month was, indeed, longer and not shorter than his number. This situation lasted 1156 years (roughly 850 years ago), when the difference became zero. The observed month has been less than the Rabban Gamliel value since that time. But being less, and not more, is perfectly legitimate given the comments by Meiri and Maimonides, and the fact that we no longer rely on witnesses. Furthermore, recall that Maimonides says that while the value of the month can be lesser or greater than 20-12-793, the deviation will be such that we will choose 29-12-793 as the result. We call this rounding to some level of precision. Here the rounding is to the nearest part of an hour. There are 1080 such parts in one hour, hence each part lasts 3 and 1/3 seconds. The deviation needs to be kept to half a part, or 1.66 seconds in order to round to 793. This requirement is met very easily given that the deviation, even at this time, is less than 0.5 seconds.

(*) This essay was posted soon after the publication of my book and well before I embarked on research into this matter. The essay makes a good tutorial and is fairly accurate considering how little research I had devoted to this topic at the time. Nevertheless, there are various oversights, omissions and outright errors in the original posting. Several values are incorrect in the last decimal place as I did not carry

calculations sufficiently far. Also the essay uses language that can be misleading. For example, I note that Maimonides indicates that the duration of the month deviates from 29-12-793 by a “small” amount. Actually, any particular month can deviate from this value by many hours; the difference in duration between the shortest and longest months is near 13 hours. Rather, Maimonides was referring to a very small change in duration of the mean lunation (29-12-793) over time. These, and other matters that could have been explained better, have been left intact. I have modified my original posting in only two respects.

I have deleted a short, last, paragraph where I speculate on the meaning of 0.51 seconds change per millennium to the mean lunation. This speculation is no longer appropriate because 0.51 is likely not the correct value given the latest (in the last few years) research on this matter. The other item that has been removed is an incorrect (and embarrassing) comment that the moon is slowing down in its orbit about the Earth. That is not the case. Rather the moon is speeding up. How it is possible that the time duration of the lunation is increasing while the moon is moving faster is explained below.

The moon and Earth are “tethered” together via gravitational attraction. There is an exchange of energy between the two and each is affected. We easily see the impact on the Earth by the phenomenon of tides. The Earth pushes against the wall of water raised by the tides and this slows the rotation of the Earth. Hence the time duration of the day is getting longer. The tides also affect the moon which experiences a torque, or twisting push, from the Earth that speeds the moon in its orbit and moves it further away from the Earth. The distance change is very small, and the amount could only be crudely estimated till laser distance-ranging corner retro-reflectors were left on the moon by the US moon landing projects (Apollo 11, 14, 15) and by the unmanned Soviet Lunokhod 2 probe. We now know, to a precision of 0.07 cm, that the moon is moving away from the Earth at the rate of 3.82 cm per year. This is a very tiny change out of nearly 400,000 km – the elliptical orbit of the moon has a perigee distance of 364,397 km and apogee distance of 406,731 km. Nevertheless, this small increase in the distance that the moon has to travel increases the time to transit one orbit about the Earth.

The reader will find my latest analysis on this topic in volume 13.2 of *The International Journal of Scientific History*, posted on web site www.dioi.org.

Revised posting September, 2006.