Chapter 2 Cycles: The Formulation of Calendars

The first unit used to measure the passage of time was probably the daily rising of the sun, the daily cycle, but that alone would not really qualify as a calendar which implies a system for organizing this natural occurrence. The other "natural" sequences are the phases of the moon, the lunar cycle, followed by the longer series of the seasons, the solar cycle. With these three obvious cycles we have the units for making a rudimentary calendar.

Ice Age hunters carved notches into mammoth tusks and reindeer bones to mark the days between phases of the moon. From these artifacts, dated between 30,000 and 10,000 B.C., we can conclude that earliest calendar was based on the phases of the moon. Of course, we know nothing of how this early calendar worked or how these people dealt with the problem that has been the difficulty of all calendar makers: none of the "natural" cycles, that is the daily cycle, the lunar cycle and the solar cycle, can be expressed in terms of each other with an integer number. The lunar cycle is a little more 29 days, the solar cycle is a little more than 365 days and the solar cycle is a little more than 12 lunations.

The Basic Calendars

The two basic types of calendars were developed with the solar calendar more popular in societies in northern latitudes where seasons were more pronounced and the lunar calendar in societies nearer the equator. The solar calendar is, of course, based on the annual trip of the earth around the sun with the natural division being the seasons. This is more pronounced in areas away from the equator. With the ascendance of agriculture, the solar calendar grew in importance which resulted in a combination of both types.

The lunar calendar is based on the cycles of the lunar phase. The lunar month is a little over 29 days and the lunar year (12 lunations) is a little over 354 days this results in a yearly 11 to 12 day drift from the solar calendar. Hebrew, Chinese, Hindu calendar and most calendars systems used in antiquity synchronized their calendar with the seasons by inserting a 13^{th} month every 2 or 3 years. An example of a purely lunar calendar is the Islamic calendar. This calendar always has 12 lunar months.

The Gregorian calendar, which is a solar calendar, has become the standard for the western world, however the church uses a lunar calendar to set ecclesiastical events, like Easter.

The Seven-Day Week

There is no record that the seven-day week cycle has ever been broken. It is likely that the week cycle has not been interrupted since the day of Moses, (c 1400 B.C.E.).

This begs the question, why seven? To most westerners the biblical reference is the obvious answer, but it is not quite so simple. The Babylonian Empire is earliest known

civilization to use the 7-day week. This unit of time may have already been in use when the Bible was written.

However, both the Babylonian and the Jewish civilizations used a lunar calendar and both attempted to have the lunar month coincides with the phases of the moon with the earliest visible crescent of the new moon marking the start of the month. In this case seven is a more convenient number since four weeks is almost equal to a lunation.

Another source for this number may simply be the five "wandering" stars of the ancient world (planets) plus the sun and the Moon. Considering the association of the days to these celestial bodies, I tend to favor this conjecture.

Perhaps it's the magical quality of the number itself, considered a "lucky" or "unlucky" number or some inherent property of the number. Both Babylonian and the Jewish civilization, for different reasons considered the seventh day "unlucky." Then, again, it could simply be that geometrically seven round objects can be arranged to form a very stable configuration that gives a perfect hexagon and thus satisfying some innate sense of order.

At first, I was hoping that the names of the days of the week were simply a corruption of the numerical sequence, one-day, two-day, … seven-day. Of course this is not the case, the days got their name long before English was even a written language. Though it can be traced to the Romans who gave them the alphabet necessary to make it a written language. The ancient Romans used an eight-day week with one day designated as a shopping day. Instead of naming the day they kept determined the day in relationship to the shopping day—either days before or after that marker. The popularity of the eight-day week diminished in favor of the seven-day over an extended period of time. Finally, Constantine, the first Christian Roman Emperor, made the seven-day week official in 321 AD. This unit of elapsed time has proved to be the most stable with the sequence not being broken in recorded history. Even with the installation of the Gregorian calendar with its ten-day adjustment in 1582 the cycle was not broken. People went to bed on Thursday, October 4th and got up on Friday, October 15th, 1582.

The seven-day had come into existence long before the Roman Empire had been founded and, no doubt, those earlier cultures had their own names, the names for the days for most of the western world can be traced to Latin, the language of that dominant power.

Different societies start the week on Sunday or Monday. It is obvious that the first two days are named for the sun and the moon respectively. Sunday is "Sun's day" which translated from the Latin "*dies solis,*" however Spain and France the Christianized name to "*domigo*" and "*dimanche*" which translates to the "Lord's day."

Monday is "Moon's day." Though the name may be different this homage to the moon is evident in most the western languages, in ancient Greek it's "*hemera selenes*," in Spanish

and French, it's "*lunes*" and "*lundi*" respectively based on the root word for the moon—"*luna*" and "*lune*."

In English, the names Tuesday, Wednesday, Thursday and Friday can be traced to the Germanic pantheon with the second day of the week being named for Tiu, a lesser-known god of war. Wednesday can be translated as "Woden's day" associated with the Norse god Odin, but directly translated "woden" means "violently insane headship." Such a name does not bode well for anyone and could be source of the "Wednesday's child is full of woe" adage. Thursday is one of the easiest to translate meaning "Thor's day," the Norse god of thunder and lightening. Friday is associated with the Norse goddess of love, marriage and fertility, Freya.

In Spanish, the names of the days show a closer association with the "wandering stars," except for Saturday which is Tuesday is "*martes"* in Spanish, named after the planet Mars, the Roman god of war. Wednesday is *"miercoles"* in Spanish closely associated with the planet Mercury and also the Roman god of speed and communication. Thursday is "jueves" in Spanish clearly tied to Jupiter from its Latin root *"Jovis."* Friday is *"viernes"* for Venus, the Roman goddess of love and beauty. Saturday, of course, is "Saturn's day" for the planet and the Roman god associated with wealth, plenty and time. The connection to the planet is broken in Spanish with *"sabado"* derived from the Jewish Sabbath.

Except for Wednesday all the English names can be associated with the planets or the corresponding Roman god. The "violently insane headship" name is unique and stands by itself. The only possible link to Rome would be Caligula who made himself a god.

The Roman Calendar

The early Roman calendar was neither a pure lunar nor a pure solar calendar, but a strange mixture of the two systems. It seems have started somewhat lunar and over ages evolved into the solar based secular calendar the western world uses now.

The first Roman calendar, attributed to Romulus, consisted of ten months for a total of 304 days ignoring the unpopular 61 days that fell in the middle of winter. The ten months were *Martius(31), Aprilis(30), Maius(31), Junius(30), Quintilis(31), Sextilis(30), September(30), October(31), November(30) and December(30)*. The last six names were simply the number corresponding to the month with *Quintilis* being the fifth month, *Sextilis* the sixth, and so on to the tenth month, *December*. The year started in the spring hence the spring equinox was always in Martius. This solar calendar feature was countered by lunar calendar feature that the months were determined by the phases of the moon. The month always started with a new moon, but there were only ten months.

The Roman calendar the days of the month were divided into day markers that fell at the start of the month, the fifth or seventh day and the middle of the month; *Calends, Nones* and *Ides* respectively. *Ides* was the full moon that always fell in the middle of the month. Days in between were expressed as a countdown to these markers.

King Numa Pompilius reformed the Romulus calendar around 700 B.C.E. adding two months, January and February, to the calendar. For some unknown reason he placed the two months before the start of the Romulus calendar year. He kept the same names for the months, but with the shift the months named by number no longer corresponded to the numerical order of the months.

To get enough days to form two lunations, he took six days from the Romulus months which gave him the opportunity to satisfy his dread of even numbers by making eleven of the twelve months have odd number days. Only February had an even number of days (28), but since this was the month for purification it was tolerable and appropriate. However even this this month was modified to mollify the Roman dread of even numbers. February was divided into two parts each with odd number of days. The first part marks the end of the religious year, the *terminalia* on the 23rd and the remaining five days form the second part. It is at this juncture that the intercalary month was inserted every few years to align the calendar with the seasons. The intercalary month consisted of 27 days, 22 additional days plus the second part of February. The resulting "leap" year consisted of 377 or 378 days depending when the intercalary month was inserted.

The intercalary system worked fairly well, but it had an inherit flaw. The *Pontifex Maximus* determined when the intercalary month was to be inserted. This was not a full time position and was usually held by a member of the Roman elite who was usually involved in Roman politics. The *Pontifex Maximus* could lengthen or shorten the term of elected officials depending on his political affiliation. In the chaotic political era of the mid first century B.C.E. the insertion of the intercalary month was quite arbitrary. This very arbitrariness led to such confusion that it prompted Julius Caesar to reform the calendar. Ironically, Julius Caesar as *Pontifex Maximus* was one the worst abusers of the system.

The Julian Calendar

The last year of the Roman calendar is the longest year in recorded history. The length of the Roman calendar year varied from 355 to 378 days depending on the "leap" year, but on 46 B.C.E., Julius Caesar added two intercalary months to align the solar year with the new calendar. The year that "never ended" had 445 days.

Since ancient times, Greek astronomers knew that the tropical year was a few minutes less than 365.25 days, but this information was not used since only Egypt had a solar calendar. It was probably there that Julius Caesar acquainted with the solar calendar. In 46 B.C.E., Julius returned to Rome with the intent to create a calendar more perfect than that of Eudoxus. He called the best philosophers and mathematicians of the time to solve the problem of the calendar. In January 1, 45 B.C.E. he installed the new reformed calendar that became the standard secular calendar for the western world unchanged and unmodified until 1582.

The Julian calendar still had twelve months but with a total of 365 days rather than 355 days of the old calendar. Every fourth year February would have an extra day. The intercalary system, the prime source of confusion and abuse in the old calendar, was abolished. Though the Julian calendar was much simpler than the system it replaced, it was not launched without problems. For the first 36 years a leap day was applied every third year rather than every fourth year, and error stemming from counting inclusively, resulting in having too many leap days. This was corrected by not having a leap day for the following 12 years after that the leap day was applied every fourth year.

The Gregorian calendar

Since the tropical year is about 11 minutes shorter than 365.25, the Julian calendar was losing time; the seasons slowly creeping away from the months associated with it. This difference resulted in a drift of about a day every 128 years. By 1582 the calendar had drifted ten days from the vernal equinox and the Church, not wanting Easter to occur in the middle winter, decided to address the problem. On February 24, 1582, Pope Gregory XIII signed a papal bull establishing the new, reformed calendar named after him.

The reform was a modification of a proposal made by Aloysius Lilius that the number of leap years in four centuries be reduced from 100 to 97. The Gregorian calendar modified the cycle of leap years in the following way:

> Every year that is exactly divisible by four is a leap year, except for years that are exactly divisible by 100; the centurial years that are exactly divisible by 400 are still leap years.

The immediate problem was how to make up the lost ten days. Should the time be made up one day a month for ten consecutive months or should it be done all at one time? Pope Gregory XIII boldly chose the latter. So people went to bed on October 4, 1582 and got up on October 15. However, some did stay up all night worried about the effects of such a jump in time. Some reported that the candles flickered, with less fanfare the hour shift for daylight savings time, it passed pretty much without incident. It was not until the end of the month, when the landlord tried to collect the rent 10 days early that there was any grumbling.

Curiously, while the year 1582 had only 355 days, October of 1582, according to the Gregorian calendar, still had 31 days. No one can quite explain what happened to those 10 days.

Not recognizing the authority of the Pope, Protestant and eastern European countries were reluctant to adopt the Gregorian calendar, but eventually yielded. The delay was long enough that the American Colonies had to adjust the calendar by 11 days. It is this gap in the time line of the Gregorian calendar that forces astronomers us use the Julian Date to calculate positions backward in time.

Julian Date

Even as use of Dionysius' Christian Era became common in ecclesiastical writings of the Middle Ages, traditional dating from regnal years continued in civil use. In the sixteenth century, Joseph Justus Scaliger tried to resolve the patchwork of historical eras by placing everything on a single system (Scaliger, 1583). Instead of introducing negative year counts, he sought an initial epoch in advance of any historical record. His numerological approach utilized three calendrical cycles: the 28-year solar cycle, the nineteen-year cycle of Golden Numbers, and the fifteen-year indiction cycle. The solar cycle is the period after which weekdays and calendar dates repeat in the Julian calendar. The cycle of Golden Numbers is the period after which moon phases repeat (approximately) on the same calendar dates. The indiction cycle was a Roman tax cycle. Scaliger could therefore characterize a year by the combination of numbers (S,G,I), where S runs from 1 through 28, G from 1 through 19, and I from 1 through 15. Scaliger noted that a given combination would recur after 7980 (= 28*19*15) years. He called this a Julian Period, because it was based on the Julian calendar year. For his initial epoch Scaliger chose the year in which S, G, and I were all equal to 1. He knew that the year 1 B.C. was characterized by the number 9 of the solar cycle, by the Golden Number 1, and by the number 3 of the indiction cycle, i.e., (9,1,3). He found that the combination (1,1,1) occurred in 4713 B.C. or, as astronomers now say, -4712. This serves as year 1 of Scaliger's Julian Period. It was later adopted as the initial epoch for the Julian day numbers

The Mayan Calendar

Using the calendar of earlier Mesoamerican civilizations as a basis, the Maya developed a complex and sophisticated calendar. It consists of three separate calendars, the *Baktun* (long count), the *Tzolkin* (divine calendar) and the *Haab* (civil calendar) that are used simultaneously. Each calendar has a set number of days before it increment by one, the *Baktun* has 144,000 days (about 394 years), *Tzolkin* has 260 days *Haab* has 365 days.

The *Haab* is a 365 day solar calendar which is divided into 18 months of 20 days and 5 nameless days. The Mayan solar year is somewhat inaccurate since it is exactly 365 days when the tropical year is 365.2422 days long.

The divine calendar, the *Tzolkin,* is a 260 day calendar with 20 periods of 13 days used to determine the time of religious events. No one is sure of the reason why the Maya chose 260 days for divine calendar, but there are several theories, one being the human gestation period, but simplest being the multiplication of their “magic” numbers, 13 and 20.

Obviously, the *Baktun* is used to keep track of longer periods of time. Basically, it counts days from creation date, a mythological starting point equivalent to August 11, 3114 BC in the Gregorian calendar.

The Maya developed a positional notation for this calendar with each position being a set multiple of the lower position. The Maya numerical system (base 20), is reflected in the

Long Count with one exception. Starting with their basic unit, the day, the positional values are:

Kin = 1 Day.
Uinal = 20 kin
Tun = 18 uinal.
Katun = 20 tun.
Baktun = 20 katun

The exception, of course, is the "Tun" and this was probably done for the practical reason that 360 days is closer to number of days in a year than 400. This left just 5 nameless days that were considered inauspicious. The Long Count is written in the following format:

Baktun.Katun.Tun.Uinal.Kin

This will provide the number of days from creation. The other two calendars provide the names of the corresponding units to set the complete date. Hence in the date notation, the number would be followed by the name.

Using the most common conversion to our current calendar 13.0.0.0.0 converts to December 21, 2012, 11:11 UTC –the infamous date that the world was supposed to end according to the Mayan calendar. Obviously this interpretation of the calendar was not only wrong, but wrong at least two level. Baktun 19 not 13 is the end of the Great Cycle, however this does not propose a new date for end of the world. In fact, the Maya had a higher cycle, the Piktun with consisted of 20 Baktuns. The Maya expected their calendar to continue.

The Maya were astute astronomers and observers who kept track of even the 584 day Venus cycle. They developed a complex and sophisticated calendar that cannot be explained in these few words. The purpose of this treatment is to provide a very basic understanding of the structure of this calendar and perhaps hone an interest in further study.