Calendars

As we have seen, a calendar is a systematic abstract device for keeping track of time, in units of days, weeks, months, seasons, years, etc. Each of the major religions of the world has developed at least one proprietary calendar (Jewish, Christian, Islamic, Hindu, Buddhist, Jain, Zoroastrian, even Baha’i). Today’s global civilization has settled on the use of the (Christian) Gregorian calendar as a common civil calendar for most purposes. We could not negotiate our lives today without calendars to assist us in organizing and planning human affairs.

Most calendars group days into months and months into years. The naturally occurring cycles of the movements of the heavenly bodies dictated to early civilizations how time should be punctuated:

- **day** [Teut. dagan = day], the period of rotation of the earth on its axis (to the ancients, the period of revolution of the sun about the earth), marked by the passage of day and night;
- **month** [Teut. = moon], roughly one lunation [L. luna = moon], or the period of revolution of the moon about the earth, marked by the evolution of the phases [Gr. phasis = appearance] of the moon, from **new**, through its **waxing** [Gr. auxein = grow] **crescent** [L. crescere = grow] and
waxing **gibbous** [L. gibbosus = humped] phases to **full** moon, then through its **waning** [Teut. wanian = lessen] gibbous and waning crescent phases back to new; also related to the length of the female menstrual period [L. mensis = month].

- **season** [L. sationum = act of sowing], in temperate climates, away from equatorial and polar regions, the annual varying cycle of nature (budding, flowering, ripening, then shedding of leaves or fruits) and weather (heat and cold, wet and dry, rain or snow, flood or drought, etc.), caused by the tilt of the earth's axis of rotation relative to the direction of the rays of the sun; otherwise loosely defined;

- **year** [Ger. jahr = year, Gr. hora = time], period of revolution of the earth about the sun (to the ancients, the period of revolution of the sun across the celestial sphere of background stars).

Clearly, then, calendars are astronomical objects, But they are religious objects, helping to establish the times of feasts and celebrations. So, too, are they mathematical constructs.

Our **week** [Old Ger. wohhe], a period of 7 days, is religious, *not* astronomical, in origin. It was instituted at the time of the Babylonian captivity of the Hebrews in 586BCE and the writing of the Pentateuch (the first five books of the Bible). It is almost equal to one quarter of a month.
Beginnings and endings

The day, the week, the month, the year, if used as standard units of time, have both a defined length of duration (each of which we have discussed above) and a time of starting (called its phase or epoch [Gr. epoche = fixed point]). Different cultures often specify different epochs for these units.

For instance, the day began
• at sunrise in ancient Egypt;
• at noon for astronomers (up until the 20th c.);
• at sunset in Babylonia and for Jews;
• at midnight in China, ancient Rome, and today.

The month began
• in Egypt, on the first day that the waning crescent was no longer visible at dawn (at or just before the actual new moon);
• in Babylonia, in ancient Rome, and in the Islamic world, on the evening when the new moon was first sighted (rather than when it first occurred);
• in China, on the day when the new moon occurs (astronomically);
• in southern parts of India, on the day after the new moon occurs;
• in northern parts of India, on the day after the full moon occurs.
The year began
• in Egypt, with the month following that in which Sopdet (Sirius) had its heliacal rising (i.e., in June);
• in Babylonia, with the month of the barley harvest (i.e., late in May);
• in ancient China, with the month that began just before the winter solstice, but in later centuries, with the second month after the solstice;
• in India, as in pre-Republican Rome, with the month containing the spring equinox (although some regions had a calendar that began at the autumnal equinox);
• in ancient Greece, with the month following the summer solstice;
• in Teutonic Northern Europe, with the month containing the winter solstice;
• and in Rome since the time of the Republic, in January.
Calendars are often linked to a culture’s creation myths at the “beginning of time” and its apocalyptic [Gr. apokalysis = revelation] myths of the “end times”. The epoch of a calendrical system is its era [L. aera = count], referring to the time when the calendar begins its count of years.

Every calendar has its current era; ours, the Gregorian Christian calendar, was designed so as to begin its count with the year of the birth of Jesus Christ, AD 1, [L. anno Domini = the year of the Lord]. (Note that the tag AD always precedes the year number.) Years before this era begins were counted backwards and labeled BC (before Christ). It was discovered centuries later that the reckoning of this era was in error by a few years; the best current estimate for the year of Jesus’ birth is 4 BC.

James Ussher, an Anglican bishop of the Church of Ireland, published a famous chronology of the world in 1650, in which he claimed, based on biblical analysis, that the date of Creation was 23 October, 4004 BC.

More and more often today, in respect to non-Christians who must use this calendar, the tags CE and BCE, for Common Era and Before the Common Era, are replacing AD and BC. (This is the standard I will adopt in this course.)
Many calendars are reckoned with an eye to civil governments. **Regnal dating** [L. regnum = royal power] is the practice of setting the epoch of an era as the year in which a pharoah, king or emperor ascends the throne. Subsequent years are numbered from then. For instance, the Japanese **nengo** calendar (in use there since the 7th c.) adopts this practice: each year is counted from the beginning of the reign of the current emperor and labeled with a special name, or nengo, selected for that reign. The year 2009 is Heisei 21, since Emperor Akihito ascended the throne in 1989, and his nengo is Heisei, meaning “achieving peace”.

End times are also often linked to calendars, especially the completion of a **millenium** [L. mille + annus = thousand + year]. **Apocalypticism** is the view that the end of the world is imminent; its appeal is ever-popular. This was particularly strong in and around the year 2000. Currently, the attention of apocalyptics is focused on the ending of the Mayan long count, set for 21 or 23 December, 2012, when the current cycle of the Mayan calendar is scheduled to complete its run. Closely related is **millennialism**, a belief in the sweeping away of current world systems and a coming of a utopian (usually Christian) world order, which is based on a 1000 year cycle of events.
These beliefs are not restricted to theological circles only: recall the furor over the Y2K computer virus scare!
Names of the parts of the calendar

**Dating**, or uniquely identifying a particular day, usually involves three labels (sometimes four), corresponding to
• the year of an era;
• the month of the year; and
• the day of the month.
• Sometimes, the day of the week is also specified.

These labeling systems generally fall into one of three types:
• a simple numbering, or use of number-based names;
• astrological naming, usually corresponding to the names of the planets; and
• religious naming, usually after names of the gods or of seasonal festivals.

Years are numbered from the beginning of an era. (The Chinese calendar is a notable exception: it names years in a 60-year cycle.) The months of the year have many systems of names. In our calendar some months (*September, October, November & December*) have number-based names [L. septem, octem, novem, decem = seven, eight, nine ten (respectively)] from the time when the Roman calendar began in March; others are tied to various reforms of the Roman calendar from which it
originated (July is named for Julius Caesar; August for Caesar Augustus); while others are religious. For instance, January was named for Janus, the deity who guarded the door of heaven, hence also of the year; it was renamed from being the eleventh month when the Roman calendar was reformed to start with January. February [L. februa = expiation offerings] was named after a feast of purification celebrated in this month. The months March, May and June are named for Roman deities: the god of war, Mars; Maia, the eldest of the seven Pleiades, the daughters of Pleione and Atlas; and Juno, the goddess of marriage and childbirth (whence comes the tradition of celebrating one’s marriage in this month). Finally, April is of uncertain origin.

The days of the month are usually not named. But the Roman calendar was an unusual exception, in that only three days of every month had special names:
• the first day of the month was the Kalends, from which our word calendar is derived;
• the eighth day was the Nones; and
• the fifteenth day was the Ides.
All other days were numbered in reference to one of these.
The Christian ecclesiological [Gr. ekklesia = church] calendar associates many of the days of the year with solemnities and feasts of saints, and there are days of the year in our civil calendar that are named based on this system (e.g., Halloween, Christmas). The French Revolutionary calendar assigned special names to every day of the year (largely intended to supplant Christian name-days!); see Appendix III of Richards’ book.

Finally, in calendars with a seven-day week (i.e., most modern calendars), the days of the week are named. Appendix II in Richards’ book list these names in 69 different languages!! Many of these lists involve names based on the “seven planets” of ancient astronomy (Sun, Moon, Mercury, Venus, Mars, Jupiter and Saturn), including the English names Sunday, Monday and Saturday. Tuesday, Wednesday, Thursday and Friday come from names of Norse gods: Tiw, god of war, was the equivalent of the Greek god (and planet) Mars; Odin (or Wotan) was the chief god of Norse mythology; Thor was the god of thunder, like the Greek god (and planet) Jupiter, and Frigga, Odin’s wife, was the Norse cognate to the Greek goddess (and planet) Venus. (Mercury had no cognate in this list.) Other languages have weekday names reflecting a simple numbering, beginning with Sunday (as in Hebrew) or Monday (as in Russian).
The fundamental mathematical problem

As we have already noted often, the day is the fundamental unit of the calendar. Its duration is based on the rotation of the earth on its axis. Days are grouped into months and years. The month is based on the lunation, the period of revolution of the moon about the earth; in particular, a lunation roughly $29 \frac{1}{2}$ days long. The year is based on the period of revolution of the earth about the sun; a year is about $365 \frac{1}{4}$ days long. So it follows that there are about $12 \frac{1}{3}$ lunations in every year. It follows from these facts that the year cannot be a uniform and whole number of days long. In order that the calendar not drift out of step with the astronomical motions, a year cannot be set uniformly at 365 days. Nor can a month/lunation be a uniform whole number of days long: should it be put at 29 or 30 days? Nor can a year be a uniform and whole number of lunations long.

In mathematical language, we say that these units of time are incommensurable [L. in + cum + mensura = not + with (the same) + measure]. This is the reason for much of the variety in the construction of calendars: there is no naturally obvious way to reconcile the inability of days,
lunation and (astronomically accurate) years to fit together into a simple systematic mathematical organization. Humans have resolved this problem in myriad ways.

One way is to devise an empirical [Gr. empeiria = experience] calendar, one in which the beginning of the year is determined by (or announced at) the sighting of some astronomical event that occurs once every year. Likewise, the first day of each month in an empirical calendar is determined by the sighting of some fixed phase of the moon. The number of days in a month or in a year, or the number of months in each year, is generally fixed, but once in a while a day or a month may need to be inserted or removed to bring the whole system back into alignment with the heavens. This system of periodic intercalation [L. inter + calare = between + to proclaim] or extracalation [L. extra + calare = outside of + to proclaim] of days or months in the year was the task of the astronomer-priests under the authority of the local ruler.

The use of an empirical calendar has the chief benefit that the calendar never drifts far from those celestial phenomena that define its units. Those who use such a calendar are always reliably tied to the motions of the heavens.
But there are many disadvantages as well:

- regular astronomical sightings require good weather, and the accuracy of the calendar is compromised when this fails to occur;
- observations of certain phenomena vary by their location on the earth, so empirical calendars, even when based on the same principles, can vary from place to place;
- even when observations are standardized by being legislated to depend on sightings at some central (national or royal) observatory, this requires information regarding the results of these observations to be communicated throughout the realm, a hardship in ancient times; moreover, centralizing a calendar often leads to its politicization (many calendar abuses crept in to the ancient Roman calendar, for instance, because rulers decided to insert or remove a day or month here or there to satisfy some whim to memorialize – or to suppress – some newsworthy event);
- finally, accurate calendars require competent astronomers, and ignorance of, or inattention to, this science caused some empirical calendars to drift out of sync with their intended designs.
Indian and Chinese calendars were empirical in their earliest stages. As astronomy improved in these lands, the patterns of the phenomena were more accurately measurable and more accurately measured. Then the calendar could be reformed to depend on mathematical rules that captured the regularity of the motions of sun and moon.

Improved accuracy of astronomical measurements led to the design of calculated calendars, which no longer need to rely on the actual sighting of events. The regularity of these events was so well understood that astronomers accurately calculated the length of an average month or year. Here are modern values of the measurements of month and year relative to days and months, given to six decimal place accuracy (which were cited above with much less accuracy):

\[
\begin{align*}
1 \text{ lunation} &= 29.530589 \text{ days} \\
1 \text{ year} &= 12.368266 \text{ lunations} \\
1 \text{ year} &= 365.242190 \text{ days} \\
12 \text{ lunations} &= 354.367066 \text{ days}
\end{align*}
\]
(One should take care to properly interpret the accuracy of these numbers. They are mean values only. As we shall learn when we more carefully study the astronomy involved, the day can vary in length by as much as 50 seconds over the course of the year, so what we mean by a day is really an average value of its length. Similarly, a lunation is not a constant unit of measure, as it is affected by the distance from the sun, which changes over the course of a year; as a result, the time between consecutive new moons can vary by as much as 7 hours depending on the time of year. Also, earth’s distance to the moon is increasing slowly with time, so even the average lunation is growing in size by about 0.02 sec per century. There is similar variation in the length of what we call a year.)

All that remains then is to ordain the appropriate number of days for each month and the appropriate number of days and months for each year in some regular repeating cycle. Strikingly, such rules enjoy considerable variety and result in a wide variety of calendar systems. Calculated calendars in Egypt, in Rome (the ancestor of our current modern calendar), and by Jewish and Islamic scholars for their religious calendars were designed with just such arithmetical rules at their foundations.
Types of calendars

We have seen that calendars are of two types, empirical or calculated, depending on whether they are based on observations to keep them in step with the sun and moon or on a collection of rules for establishing their cycles.

There is an almost endless variety of calculated calendars, but most fall under three broad categories:

- **lunar** [L. luna = moon] (as the Islamic calendar), in which months are defined to contain a fixed number of days, but years contain varying numbers of months;
- **solar** [L. sol = sun] (as the Roman calendar and its later Christian reforms, including our current calendar), in which the year is defined to contain a fixed number of days, but there is either no month at all or the month is not strongly linked to the phases of the moon;
- **lunisolar** (e.g., the Babylonian calendar and its later Alexandrian Greek reforms), in which attempts are made to preserve elements of both cycles, the lunar month and the solar year.
Lunar calendars focus on keeping the month in step with the phases of the moon by fixing the number of days in the month. The chief concern is how to reconcile the fact that the month includes somewhat more than \(29\frac{1}{2}\) days, so a calendar based on months that alternate 29 and 30 days in length eventually drifts out of phase with the moon. The answer involves intercalating a month every so often: some years will include a 13th month.

Solar calendars focus on keeping the year in step with the seasons (the motion of the sun). The chief concern is how to reconcile the fact that the year contains more than 365 days, so a day is intercalated every so often: some years will include a 366th day.

Lunisolar calendars try to match both months to lunations and years to seasonal cycle. A sophisticated plan of intercalations is required to keep both the lunar and solar cycles synchronized [Gr. syn + chronos = together + time].

A few important calendars resist classification into these categories. We will make special note of this when we study them later on.