The Western Calendar And Calendar Reforms

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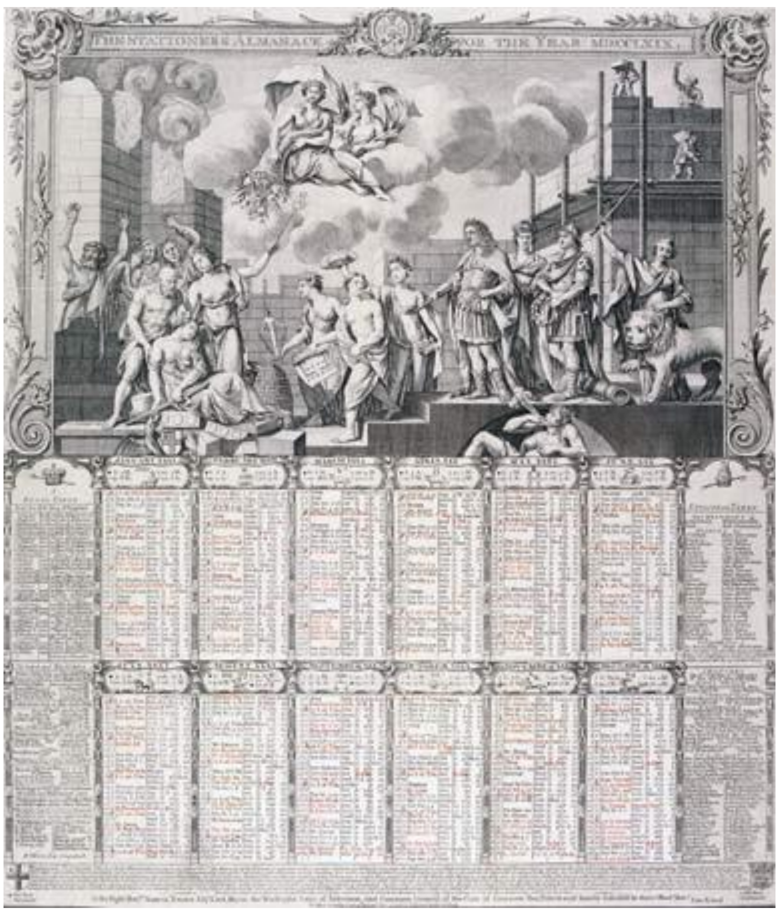
The calendar now in general worldwide use had its origin in the desire for a solar calendar that kept in step with the seasons and possessed fixed rules of intercalation. Because it developed in Western Christendom, it had also to provide a method for dating movable religious feasts, the timing of which had been based on a lunar reckoning. To reconcile the lunar and solar schemes, features of the Roman republican calendar and the Egyptian calendar were combined.



The Stationers' Almanack for 1769, with calendar below. The illustration on top is of an allegorical relief found on the west side of a monument to the London fire of 1666.*© City of London Libraries and Guildhall Art Gallery/Heritage-Images*

The Roman republican calendar was basically a lunar reckoning and became increasingly out of phase with the seasons as time passed. By about

50 BCE the vernal equinox that should have fallen late in March fell on the Ides of May, some eight weeks later, and it was plain that this error would continue to increase. Moreover, the behaviour of the Pontifices (*see above* The early Roman calendar) made it necessary to seek a fixed rule of intercalation in order to put an end to arbitrariness in inserting months.

In addition to the problem of intercalation, it was clear that the average Roman republican year of 366.25 days would always show a continually increasing disparity with the seasons, amounting to one month every 30 years, or three months a century. But the great difficulty facing any reformer was that there seemed to be no way of effecting a change that would still allow the months to remain in step with the phases of the Moon and the year with the seasons. It was necessary to make a fundamental break with traditional reckoning to devise an efficient seasonal calendar.

The Julian calendar

In the mid-1st century BCE Julius Caesar invited astronomer Sosigenes of Alexandria to advise him about the reform of the calendar, and Sosigenes decided that the only practical step was to abandon the lunar calendaraltogether. Months must be arranged on a seasonal basis, and a tropical (solar) year used, as in the Egyptian calendar, but with its length taken as 365 $^1/_4$ days.

To remove the immense discrepancy between calendar date and equinox, it was decided that the year known in modern times as 46 BCE should have two intercalations. The first was the customary intercalation of the Roman republican calendar due that year, the insertion of 23 days following February 23.

The secondintercalation, to bring the calendar in step with the equinoxes, was achieved by inserting two additional months between the end of November and the beginning of December. This insertion amounted to an addition of 67 days, making a year of no less than 445 days and causing the beginning of March 45 BCE in the Roman republican calendar to fall on what is still called January 1 of the Julian calendar.

Previous errors having been corrected, the next step was to prevent their recurrence. Here Sosigenes' suggestion about a tropical year was adopted and any pretense to a lunar calendar was rejected. The figure of 365.25 days was accepted for the tropical year, and, to achieve this by a simple civil reckoning, Caesar directed that a calendar year of 365 days be adopted and that an extra day be intercalated every fourth year. Since February ordinarily had 28 days, February 24 was the sixth day (using inclusive numbering) before the Kalendae, or beginning of March, and was known as the *sexto-kalendae*; the intercalary day, when it appeared, was in effect a "doubling" of the *sexto-kalendae* and was called the *bis-sexto-kalendae*. This practice led to the term *bissextile* being used to refer to such a leap year. The name leap year is a later connotation, probably derived from the Old Norse *hlaupa* ("to leap") and used because, in a bissextile year, any fixed festival after February leaps forward, falling on the second weekday from that on which it fell the previous year, not on the next weekday as it would do in an ordinary year.

Apparently, the Pontifices misinterpreted the edict and inserted the intercalation too frequently. The error arose because of the Roman practice of inclusive numbering, so that an intercalation once every fourth year meant to them intercalating every three years, because a bissextile year was counted as the first year of the subsequent four-year period. This error continued undetected for 36 years, during which period 12 days instead of nine were added. The emperor Augustus then made a correction by omitting intercalary days between 8 BCEand 8 CE. As a consequence, it was not until several decades after its inception that the Julian calendar came into proper operation, a fact that is important in chronology but is all too frequently forgotten.

It seems that the months of the Julian calendar were taken over from the Roman republican calendar but were slightly modified to provide a more even pattern of numbering. The republican calendar months of March, May, and Quintilis (July), which had each possessed 31 days, were retained unaltered. Although there is some doubt about the specific details, changes may have occurred in the following way. Except for October, all the months that had previously had only 29 days had either one or two days added. January, September, and November received two days, bringing their totals to 31, while April, June, Sextilis (August), and December received one day each, bringing their totals to 30. October was reduced by one day to a total of 30 days and February increased to 29 days, or 30 in a bissextile year. With the exception of February, the scheme resulted in months having 30 or 31 days alternately throughout the year. And in order to help farmers, Caesar issued an almanac showing on which dates of his new calendar various seasonal astronomical phenomena would occur.

These arrangements for the months can only have remained in force for a short time, because in 8 BCE changes were made by Augustus. In 44 BCE, the second year of the Julian calendar, the Senate proposed that the name of the month Quintilis be changed to Julius (July), in honour of Julius Caesar, and in 8 BCE the name of Sextilis was similarly changed to Augustus (August). Perhaps because Augustus felt that his month must have at least as many days as Julius Caesar's, February was reduced to 28 days and August increased to 31. But because this made three 31-day months (July, August, and September) appear in succession, Augustus is supposed to have reduced September to 30 days, added a day to October to make it 31 days, reduced November by one day to 30 days, and increased December from 30 to 31 days, giving the months the lengths they have today.

Several scholars, however, believe that Caesar originally left February with 28 days (in order to avoid affecting certain religious rites observed in honour of the gods of the netherworld) and added two days to Sextilis for a total of 31; January, March, May, Quintilis, October, and December also had 31 days, with 30 days for April, June, September, and November. The subsequent change of Sextilis to Augustus therefore involved no addition of days to the latter.

The Julian calendar retained the Roman republican calendar method of numbering the days of the month. Compared with the present system, the Roman numbering seems to run backward, for the first day of the month was known as the Kalendae, but subsequent days were not enumerated as so many after the Kalendae but as so many before the following Nonae ("nones"), the day called nonae being the ninth day before the Ides (from *iduare*, meaning "to divide"), which occurred in the middle of the month and were supposed to coincide with the Full Moon. Days after the Nonae and before the Ides were numbered as so many before the Ides, and those after the Ides as so many before the Kalendae of the next month.

It should be noted that there were no weeks in the original Julian calendar. The days were designated either *dies fasti* or *dies nefasti*, the former being business days and days on which the courts were open; this had been the practice in the Roman republican calendar. Julius Caesar designated his additional days all as *dies fasti*, and they were added at the end of the month so that there was no interference with the dates traditionally fixed for *dies comitiales* (days on which public assemblies might be convened) and *dies festi* and *dies feriae* (days for religious festivals and holy days). Originally, then, the Julian calendar had a permanent set of dates for administrative matters. The official introduction of the seven-day week by Emperor Constantine I in the 4th century CE disrupted this arrangement.

It appears, from the date of insertion of the intercalary month in the Roman republican calendar and the habit of designating years by the names of the consuls, that the calendar year had originally commenced in March, which was the date when the new consul took office. In 222 BCE the date of assuming duties was fixed as March 15, but in 153 BCE it was transferred to the Kalendae of January, and there it remained. January therefore became the first month of the year, and in the western region of the Roman Empire, this practice was carried over into the Julian calendar. In the eastern provinces, however, years were often reckoned from the accession of the reigning emperor, the second beginning on the first New Year's day after the accession; and the date on which this occurred varied from one province to another.

The Gregorian calendar

The Julian calendar year of 365.25 days was too long, since the correct value for the tropical year is 365.242199 days. This error of 11 minutes 14 seconds per year amounted to almost one and a half days in two centuries, and seven days in 1,000 years. Once again the calendar became increasingly out of phase with the seasons. From time to time, the problem was placed before church councils, but no action was taken because the astronomers who were consulted doubted whether enough precise information was available for a really accurate value of the tropical year to be obtained.

Astronomical clock from the 14th century that can be used to determine religious feast days until the year 2019; in the cathedral of St. John the Baptist, Lyon, France.© *Jakez/Shutterstock.com*

By 1545, however, the vernal equinox, which was used in determining Easter, had moved 10 days from its proper date; and in December, when the Council of Trentmet for the first of its sessions, it authorized Pope Paul III to take action to correct the error. Correction required a solution, however, that neither Paul III nor his successors were able to obtain in satisfactory form until nearly 1572, the year of election of Pope Gregory XIII. Gregory found various proposals awaiting him and agreed to issue a bull that the Jesuit astronomer Christopher Clavius (1537–1612) began to draw up, using suggestions made by the astronomer and physician Luigi Lilio (also known as Aloysius Lilius; died 1576).

The papal bull *Inter gravissimas* ("In the gravest concern") was issued on February 24, 1582. First, in order to bring the vernal equinox back to March 21, the day following the Feast of St. Francis (that is, October 5) was to become October 15, thus omitting 10 days. Second, to bring the year closer to the true tropical year, a value of 365.2422 days was accepted. This value differed by 0.0078 days per year from the Julian calendar reckoning, amounting to 0.78 days per century, or 3.12 days every 400 years. It was therefore promulgated that three out of every four centennial years should be common years, that is, not leap years; and this practice led to the rule that no centennial years should be leap years unless exactly divisible by 400. Thus, 1700, 1800, and 1900 were not leap years, as they would have been in the Julian calendar, but the year 2000 was. The reform, which established what became known as the Gregorian calendar and laid down rules for calculating the date of Easter, was well received by such astronomers as Johannes Kepler and Tycho Brahe and by the Catholic princes of Europe. Many Protestants, however, saw it as the work of the Antichrist and refused to adopt it. Eventually all of Europe, as late as 1918 in the case of Russia, adopted the Gregorian calendar.

The date of Easter; epacts

Easter was the most important feast of the Christian church, and its place in the calendar determined the position of the rest of the church's movable feasts (*see*church year). Because its timing depended on both the Moon's phases and the vernal equinox, ecclesiastical authorities had to seek some way of reconcilinglunar and solar calendars. Some simple form of computation, usable by nonastronomers in remote places, was desirable. There was no easy or obvious solution, and to make things more difficult there was no unanimous agreement on the way in which Easter should be calculated, even in a lunar calendar.

Easter, being the festival of the Resurrection, had to depend on the dating of the Crucifixion, which occurred three days earlier and just before the Jewish Passover. The Passover was celebrated on the 14th day of Nisan, the first month in the Jewish religious year—that is, the lunar month the 14th day of which falls on or next after the vernal equinox. The Christian churches in the eastern Mediterranean area celebrated Easter on the 14th of Nisan on whatever day of the week it might fall, but the rest of Christendom adopted a more elaborate reckoning to ensure that it was celebrated on a Sunday in the Passover week.

To determine precisely how the Resurrection and Easter Day should be dated, reference was made to the Gospels; but, even as early as the 2nd century CE, difficulties had arisen, because the synoptic Gospels (Matthew, Mark, and Luke) appeared to give a different date from the Gospel According to John for the Crucifixion. This difference led to controversy that was later exacerbated by another difficulty caused by the Jewish reckoning of a day from sunset to sunset. The question arose of how the evening of the 14th day should be calculated, and some—the Quintodecimans—claimed that it meant one particular evening, but others—the Quartodecimans—claimed that it meant the evening before, since sunset heralded a new day. Both sides had their protagonists, the Eastern churches supporting the Quartodecimans, the Western churches the Quintodecimans. The question was finally decided by the Western church in favour of the Quintodecimans, though there is debate whether this was at the Council of Nicaea in 325 or later. The Eastern churches decided to retain the Quartodeciman position, and the church in Britain, which had few links with European churches at this time, retained the Quartodeciman position until Roman missionaries arrived in the 6th century, when a change was made. The dating of Easter in the Gregorian calendar was based on the decision of the Western church, which decreed that Easter should be celebrated on the Sunday immediately following the (Paschal) Full Moon that fell on or after the vernal equinox, which they took as March 21. The church also ordered that if this Full Moon fell on a Sunday, the festival should be held seven days later.

With these provisions in mind, the problem could be broken down into two parts: first, devising a simple but effective way of calculating the days of the week for any date in the year and, second, determining the date of the Full Moons in any year. The first part was solved by the use of a letter code derived from a similar Roman system adopted for determining market days. For ecclesiastical use, the code gave what was known as the Sunday, or dominical, letter.

The seven letters A through G are each assigned to a day, consecutively from January 1 so that January 1 appears as A, January 2 as B, to January 7 which appears as G, the cycle then continuing with January 8 as A, January 9 as B, and so on. Then in any year the first Sunday is bound to be assigned to one of the letters A–G in the first cycle, and all Sundays in the year possess that dominical letter. For example, if the first Sunday falls on January 3, C will be the dominical letter for the whole year. No dominical letter is placed against the intercalary day, February 29, but, since it is still counted as a weekday and given a name, the series of letters moves back one day every leap year after intercalation. Thus, a leap year beginning with the dominical letter C will change to a year with the dominical letter B on March 1; and in lists of dominical letters, all leap years are given a double letter notation, in the example just quoted, CB. It is not difficult to see what dominical letter or letters apply to any particular year, and it is also a comparatively simple matter to draw up a table of dominical letters for use in determining Easter Sunday. The possible dates on which Easter Sunday can fall are written down—they run from March 22 through April 25—and against them the dominical letters for a cycle of seven years. Once the dominical letter for a year is known, the possible Sundays for celebrating Easter can be read directly from the table. This system does not, of course, completely determine Easter; to do so, additional information is required.

This must provide dates for Full Moons throughout the year, and for this a lunar cycle like the Metonic cycle was originally used. Tables were prepared, again using the range of dates on which Easter Sunday could appear, and against each date a number from one through 19 was placed. This number indicated which of the 19 years of the lunar cycle would give a Full Moon on that day. From medievaltimes these were known as golden numbers, possibly from a name used by the Greeks for the numbers on the Metonic cycle or because gold is the colour used for them in manuscript calendars.

The system of golden numbers was introduced in 530, but the numbers were arranged as they should have been if adopted at the Council of Nicaea two centuries earlier; and the cycle was taken to begin in a year when the New Moonfell on January 1. Working backward, chronologers found that this date had occurred in the year preceding 1 CE, and therefore the golden number for any year is found by adding one to the year and dividing that sum by 19. The golden number is the remainder or, if there is no remainder, 19.

To compute the date of Easter, the medieval chronologer computed the golden number for the year and then consulted his table to see by which date this number lay. Having found this date, that of the first Full Moon after March 20, he consulted his table of dominical letters and saw the next date against which the dominical letter for that year appeared; this was the Sunday to be designated Easter. The method, modified for dropping centennial leap years as practiced in the Gregorian calendar, is still given in the English prayer book, although it was officially discarded when the Gregorian calendar was introduced.

The system of golden numbers was eventually rejected because the astronomical Full Moon could differ by as much as two days from the date they indicated. It was Lilius who had proposed a more accurate system based on one that had already been in use unofficially while the Julian calendar was still in force. Called the epact—the word is derived from the Greek *epagein*, meaning “to intercalate”—this was again a system of numbers concerned with the Moon’s phases, but now indicating the age of the Moon on the first day of the year, from which the age of the Moon on any day of the year may be found, at least approximately, by counting, using alternately months of 29 and 30 days.

The epact as previously used was not, however, completely accurate because, like the golden number, it had been based on the Metonic cycle. This 19-year cycle was in error, the discrepancy amounting to eight days every 2,500 years. A one-day change on certain centennial years was then instituted by making the computed age of the Moon one day later seven times, at 300-year intervals, and an eighth time after a subsequent 400 years. This operation was known as the lunar correction, but it was not the only correction required; there was another.

Because the Gregorian calendar used a more accurate value for the tropical year than the Julian calendar and achieved this by omitting most centennial leap years, Clavius decided that, when the cycle of epacts reached an ordinary centennial year, the number of the epact should be reduced by one; this reduction became known as the solar correction.

One advantage of the epact number was that it showed the age of the Moon on January 1 and so permitted a simple calculation of the dates of New Moon and Full Moon for the ensuing year. Another was that it lent itself to the construction of cycles of 30 epact numbers, each diminishing by one from the previous cycle, so that, when it became necessary at certain centennial years to shift from one cycle to another, there would still be a cycle ready that retained a correct relationship between dates and New Moons.

For determining Easter, a table was prepared of the golden numbers, one through 19, and below them the cycles of epacts for about 7,000 years; after this time, all the epact cycles are repeated. A second table was then drawn up, giving the dates of Easter Full Moons for different epact numbers. Once the epact for the year was known, the date of the Easter Full Moon could be immediately obtained, while consultation of a table of dominical letters showed which was the next Sunday. Thus, the Gregorian system of epacts, while more accurate than the old golden numbers, still forced the chronologer to consult complex astronomical tables.

Adoption in various countries

The derivation of the term *style* for a type of calendar seems to have originated sometime soon after the 6th century as a result of developments in calendar computation in the previous 200 years. In 463 CE Victorius (or Victorinus) of Aquitaine, who had been appointed by Pope Hilarius to undertake calendar revision, devised the Great Paschal (i.e., Passover) period, sometimes later referred to as the Victorian period. It was a combination of the solar cycle of 28 years and the Metonic 19-year cycle, bringing the Full Moon back to the same day of the month, and amounted to 28 × 19, or 532 years. In the 6th century this period was used by Dionysius Exiguus (Denis the Little) in computing the date of Easter, because it gave the day of the week for any day in any year, and so it also became known as the Dionysian period. Dionysius took the year now called 532 CE as the first year of a new Great Paschal period and the year now designated 1 BCE as the beginning of the previous cycle. In the 6th century it was the general belief that this was the year of Christ's birth, and because of this Dionysius introduced the concept of numbering years consecutively through the Christian era. The method was adopted by some scholars but seems only to have become widely used after its popularization by the Venerable Bede of Jarrow (673?–735), whose reputation for scholarship was very high in Western Christendom in the 8th century. This system of BCE/CE numbering threw into relief the different practices, or styles, of reckoning the beginning of the year then in use. When the Gregorian calendar firmly established January 1 as the beginning of its year, it was widely referred to as the New Style calendar, with the Julian the Old Style calendar. In Britain, under the Julian calendar, the year had first begun on December 25 and then, from the 14th century onward, on March 25. Because of the division of the Eastern and Western Christian churches and of Protestants and Roman Catholics, the obvious advantages of the Gregorian calendar were not accepted everywhere, and in some places adoption was extremely slow. In France, Italy, Luxembourg, Portugal, and Spain, the New Style calendar was adopted in 1582, and it was in use by most of the German Roman Catholic states as well as by

Belgium and part of the Netherlands by 1584. Switzerland's change was gradual, on the other hand, beginning in 1583 and being completed only in 1812. Hungary adopted the New Style in 1587, and then there was a pause of more than a century before the first Protestant countries made the transition from the Old Style calendar. In 1699–1700, Denmark and the Dutch and German Protestant states embraced the New Style, although the Germans declined to adopt the rules laid down for determining Easter. The Germans preferred to rely instead on astronomical tables and specified the use of the *Tabulae Rudolphinae* (1627; "Rudolphine Tables"), based on the 16th-century observations of Tycho Brahe. They acceded to the Gregorian calendar rules for Easter only in 1776. Britain adopted the New Style in 1752 and Sweden in 1753, although the Swedes, because they had in 1740 followed the German Protestants in using their astronomical methods for determining Easter, declined to adopt the Gregorian calendar rules until 1844. Japan adopted the New Style in 1873; Egypt adopted it in 1875; and between 1912 and 1917 it was accepted by Albania, Bulgaria, China, Estonia, Latvia, Lithuania, Romania, and Turkey. The now-defunct Soviet Union adopted the New Style in 1918, and Greece in 1923.

In Britain and the British dominions, the change was made when the difference between the New and Old Style calendars amounted to 11 days: the lag was covered by naming the day after September 2, 1752, as September 14, 1752. There was widespread misunderstanding among the public, however, even though legislation authorizing the change had been framed to avoid injustice and financial hardship. The Alaskan territory retained the Old Style calendar until 1867, when it was transferred from Russia to the United States.

Calendar reform since the mid-18th century

The French republican calendar

In late 18th-century France, with the approach of the French Revolution, demands began to be made for a radical change in the civil calendar that would divorce it completely from any ecclesiastical connections. The first attacks on the Gregorian calendar and proposals for reform came in 1785 and 1788, the changes being primarily designed to divest the calendar of all its Christian associations. After the storming of the Bastille in July 1789, demands became more vociferous, and a new calendar, to start from "the first year of liberty," was widely spoken about. In 1793 the National Convention appointed Charles-Gilbert Romme, president of the committee of public instruction, to take charge of the reform. Technical matters were entrusted to the mathematicians Joseph-Louis Lagrangeand Gaspard Monge and the renaming of the months to the Paris deputy to the convention, Philippe Fabre d'Églantine. The results of their deliberations were submitted to the convention in September of the same year and were immediately accepted, it being promulgated that the new calendar should become law on October 5.

The French republican calendar, as the reformed system came to be known, was taken to have begun on September 22, 1792, the day of the proclamation of the Republic and, in that year, the date also of the autumnal equinox. The total number of days in the year was fixed at 365, the same as in the Julian and Gregorian calendars, and this was divided into 12 months of 30 days each, the remaining five days at year's end being devoted to festivals and vacations. These were to fall between September 17 and 22 and were specified, in order, to be festivals in honour of virtue, genius, labour, opinion, and rewards. In a leap year an extra festival was to be added—the festival of the Revolution. Leap years were retained at the same frequency as in the Gregorian calendar, but it was enacted that the first leap year should be year 3, not year 4 as it would have been if the Gregorian calendar had been followed precisely in this respect. Each four-year period was to be known as a *Franciade*.

The seven-day week was abandoned, and each 30-day month was divided into three periods of 10 days called *décades*, the last day of a *décade* being a rest day. It was also agreed that each day should be divided into decimal parts, but this was not popular in practice and was allowed to fall into disuse.

The months themselves were renamed so that all previous associations should be lost, and Fabre d'Églantine chose descriptive names as follows (the descriptive nature and corresponding Gregorian calendar dates for years 1, 2, 3, 5, 6, and 7 are given in parentheses):

- Vendémiaire ("vintage," September 22 to October 21),
- Brumaire ("mist," October 22 to November 20),
- Frimaire ("frost," November 21 to December 20),
- Nivôse ("snow," December 21 to January 19),
- Pluviôse ("rain," January 20 to February 18),
- Ventôse ("wind," February 19 to March 20),
- Germinal ("seedtime," March 21 to April 19),
- Floréal ("blossom," April 20 to May 19),
- Prairial ("meadow," May 20 to June 18),
- Messidor ("harvest," June 19 to July 18),
- Thermidor ("heat," July 19 to August 17), and
- Fructidor ("fruits," August 18 to September 16).

The French republican calendar was short-lived, for while it was satisfactory enough internally, it clearly made for difficulties in communication abroad because its months continually changed their relationship to dates in the Gregorian calendar. In

September 1805, under the Napoleonic regime, the calendar was virtually abandoned, and on January 1, 1806, it was replaced by the Gregorian calendar.

Soviet calendar reforms

When Soviet Russia undertook its calendar reform in February 1918, it merely moved from the Julian calendar to the Gregorian. This move resulted in a loss of 13 days, so that February 1, 1918, became February 14.

Modern schemes for reform

The current calendar is not without defects, and reforms are still being proposed. Astronomically, it really calls for no improvement, but the seven-day week and the different lengths of months are unsatisfactory to some. Clearly, if the calendar could have all festivals and all rest days fixed on the same dates every year, as in the original Julian calendar, this arrangement would be more convenient, and two general schemes have been put forward—the International Fixed Calendar and the World Calendar.

A perpetual calendar makes it possible to find the correct day of the week for any date over a wide range of years.© *Dan Tataru/Shutterstock.com*

The International Fixed Calendar is essentially a perpetual Gregorian calendar, in which the year is divided into 13 months, each of 28 days, with an additional day at the end. Present month names are retained, but a new month named Sol is intercalated between June and July. The additional day follows December 28 and bears no designation of month date or weekday name, while the same would be true of the day intercalated in a leap year after June 28. In this calendar, every month begins on a Sunday and ends on a Saturday.

It is claimed that the proposed International Fixed Calendar does not conveniently divide into quarters for business reckoning; and the World Calendaris designed to remedy this deficiency, being divided into four quarters of 91 days each, with an additional day at the end of the year. In each quarter, the first month is of 31 days and the second and third of 30 days each. The extra day comes after December 30 and bears no month or weekday designation, nor does the intercalated leap year day that follows June 30. In the World Calendar January 1, April 1, July 1, and October 1 are all Sundays. Critics point out that each month extends over part of five weeks, and each month within a given quarter begins on a different day. Nevertheless, both these proposed reforms seem to be improvements over the present system that contains so many variables.

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