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Gregorian calendar

The **Gregorian calendar** is internationally the most widely used civil calendar.[1][2][Note 1] It is named after Pope Gregory XIII, who introduced it in October 1582.

It was a refinement to the Julian calendar[3] involving an approximately 0.002% correction in the length of the calendar year. The motivation for the reform was to stop the drift of the calendar with respect to the equinoxes and solstices—particularly the northern vernal equinox, which helps set the date for Easter. Transition to the Gregorian calendar would restore the holiday to the time of the year in which it was celebrated when introduced by the early Church. The reform was adopted initially by the Catholic countries of Europe. Protestants and Eastern Orthodox countries continued to use the traditional Julian calendar and adopted the Gregorian reform, one by one, after a time, at least for civil purposes and for the sake of convenience in international trade. The last European country to adopt the reform was Greece, in 1923. Many (but not all) countries that have traditionally used the Julian calendar, or the Islamic or other religious calendars, have come to adopt the Gregorian calendar for civil purposes.

The Gregorian reform contained two parts: a reform of the Julian calendar as used prior to Pope Gregory XIII's time, and a reform of the lunar cycle used by the Church with the Julian calendar to calculate the date of Easter. The reform was a modification of a proposal made by Aloysius Lilius,[4] who proposed to reduce the number of leap years that occur in every four centuries from 100 to 97, by making 3 out of 4 centurial years common years instead of leap years. Lilius also produced an original and practical scheme for adjusting the epacts of the moon when calculating the annual date of Easter, solving a long-standing obstacle to calendar reform.

The Gregorian reform modified the Julian calendar's scheme of leap years as follows:

> Every year that is exactly divisible by four is a leap year, except for years that are exactly divisible by 100, but these centurial years are leap years if they are exactly divisible by 400. For example, the years 1700, 1800, and 1900 are not leap years, but the year 2000 is.[5]

In addition to the change in the mean length of the calendar year from 365.25 days (365 days 6 hours) to 365.2425 days (365 days 5 hours 49 minutes 12 seconds), a reduction of 10 minutes 48 seconds per year, the Gregorian calendar reform also dealt with the accumulated difference between these lengths. The canonical Easter tables were devised at the end of the third century, when the vernal equinox fell either on 20 March or 21 March depending on the year's position in the leap year

2018 in various calendars

Gregorian calendar	2018 *MMXVIII*
Ab urbe condita	2771
Armenian calendar	1467 ԹՎ ՌՆԿԷ
Assyrian calendar	6768
Bahá'í calendar	174–175
Balinese saka calendar	1939–1940
Bengali calendar	1425
Berber calendar	2968
British Regnal year	66 Eliz. 2 – 67 Eliz. 2
Buddhist calendar	2562
Burmese calendar	1380
Byzantine calendar	7526–7527

cycle. As the rule was that the full moon preceding Easter was not to precede the equinox, the date was fixed at 21 March for computational purposes and the earliest date for Easter was fixed at 22 March. The Gregorian calendar reproduced these conditions by removing ten days.[6]

To unambiguously specify a date, dual dating or Old Style and New Style dates are sometimes used. Dual dating gives two consecutive years for a given date because of differences in the starting date of the year or to give both the Julian and the Gregorian dates. The "Old Style" (O.S.) and "New Style" (N.S.) notations indicate either that the start of the Julian year has (or has not) been adjusted to start on 1 January (even though documents written at the time use a different start of year), or that a date conforms to the (old) Julian calendar rather than the (new) Gregorian.[Note 2]

The Gregorian calendar continued to use the previous calendar era (year-numbering system), which counts years from the traditional date of the nativity (*Anno Domini*), originally calculated in the 6th century by Dionysius Exiguus.[7] This year-numbering system, also known as Dionysian era or Common Era, is the predominant international standard today.[Note 3]

Chinese calendar	丁酉年 (Fire Rooster) 4714 or 4654 — *to* — 戊戌年 (Earth Dog) 4715 or 4655
Coptic calendar	1734–1735
Discordian calendar	3184
Ethiopian calendar	2010–2011
Hebrew calendar	5778–5779
Hindu calendars	
- *Vikram Samvat*	2074–2075
- *Shaka Samvat*	1939–1940
- *Kali Yuga*	5118–5119
Holocene calendar	12018
Igbo calendar	1018–1019
Iranian calendar	1396–1397
Islamic calendar	1439–1440
Japanese calendar	Heisei 30 (平成３０年)

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Javanese calendar	1951–1952
Juche calendar	107
Julian calendar	Gregorian minus 13 days
Korean calendar	4351
Minguo calendar	ROC 107 民國107年
Nanakshahi calendar	550
Thai solar calendar	2561
Tibetan calendar	阴火鸡年 (female Fire-Rooster) 2144 or 1763 or 991 *— to —* 阳土狗年 (male Earth-Dog) 2145 or 1764 or 992
Unix time	1514764800 – 1546300799

Description

Christopher Clavius (1538–1612), one of the main authors of the reform.

Pope Gregory XIII in an early 17th-century engraving.

A year is divided into twelve months

No.	Name	Length in days
1	January	31
2	February	28 (29 in leap years)
3	March	31
4	April	30
5	May	31
6	June	30
7	July	31
8	August	31
9	September	30
10	October	31
11	November	30
12	December	31

The Gregorian calendar is a solar calendar. A regular Gregorian year consists of 365 days, but as in the Julian calendar, in certain years, a leap year, a leap day is added to February. In the Julian calendar a leap year occurs every 4 years, but the Gregorian calendar omits a leap day in three of every 400 years. In the Julian calendar, the leap day was inserted by doubling 24 February, and the Gregorian reform did not change the date of the leap day. In the modern period, it has become customary to number the days from the beginning of the month, and 29 February is typically considered as the leap day. Some churches, notably the Roman Catholic Church, delay February festivals after the 23rd by one day in leap years.[9]

Gregorian years are identified by consecutive year numbers.[10] The cycles repeat completely every 146,097 days, which equals 400 years.[Note 4][Note 5] Of these 400 years, 303 are regular years of 365 days and 97 are leap years of 366 days. A mean calendar year is 365 $\frac{97}{400}$ days = 365.2425 days, or 365 days, 5 hours, 49 minutes and 12 seconds.[Note 6]

A calendar date is fully specified by the year (numbered by some scheme beyond the scope of the calendar itself), the month (identified by name or number), and the day of the month (numbered sequentially starting at 1). Although the calendar year currently runs from 1 January to 31 December, at previous times year numbers were based on a different starting point within the calendar (see the "beginning of the year" section below).

Gregorian reform

The Gregorian calendar was a reform of the Julian calendar. It was instituted in 1582 by Pope Gregory XIII, after whom the calendar was named, by papal bull *Inter gravissimas* dated 24 February 1582.[3] The motivation for the adjustment was to bring the date for the celebration of Easter to the time of year in which it was celebrated when it was introduced by the early Church. The error in the Julian calendar (its assumption that there are exactly 365.25 days in a year) had led to the date of the equinox according to the calendar drifting from the observed reality, and thus an error had been introduced into the calculation of the date of Easter.

Although a recommendation of the First Council of Nicaea in 325 specified that all Christians should celebrate Easter on the same day, it took almost five centuries before virtually all Christians achieved that objective by adopting the rules of the Church of Alexandria (see Easter for the issues which arose).[Note 7]

Background

Because the date of Easter was tied to the Spring Equinox, the Roman Catholic Church considered the seasonal drift in the date of Easter undesirable. The Church of Alexandria celebrated Easter on the Sunday after the 14th day of the moon (computed using the Metonic cycle) that falls on or after the vernal equinox, which they placed on 21 March. However, the Church of Rome still regarded 25 March (Lady Day) as the equinox (until 342), and used a different cycle to compute the day of the moon.[12] In the Alexandrian system, since the 14th day of the Easter moon could fall at earliest on 21 March its first day could fall no earlier than 8 March and no later than 5 April. This meant that Easter varied between 22 March and 25 April. In Rome, Easter was not allowed to fall later than 21 April, that being the day of the *Parilia* or birthday of Rome and a pagan festival. The first day of the Easter moon could fall no earlier than 5 March and no later than 2 April.

Easter was the Sunday after the 15th day of this moon, whose 14th day was allowed to precede the equinox. Where the two systems produced different dates there was generally a compromise so that both churches were able to celebrate on the same day. By the 10th century all churches (except some on the eastern border of the Byzantine Empire) had adopted the Alexandrian Easter, which still placed the vernal equinox on 21 March, although Bede had already noted its drift in 725—it had drifted even further by the 16th century.[13]

Worse, the reckoned Moon that was used to compute Easter was fixed to the Julian year by a 19-year cycle. That approximation built up an error of one day every 310 years, so by the 16th century the lunar calendar was out of phase with the real Moon by four days.

European scholars had been well aware of the calendar drift since the early medieval period. Bede, writing in the 8th century, showed that the accumulated error in his day was more than three days. Roger Bacon in c. 1200 estimated the error at seven or eight days. Dante, writing c. 1300, was aware of the need of a calendar reform. The first attempt to go forward with such a reform was undertaken by Pope Sixtus IV, who in 1475 invited Regiomontanus to the Vatican for this purpose. However, the project was interrupted by the death of Regiomontanus shortly after his arrival in Rome.[14] The increase of astronomical knowledge and the precision of observations towards the end of the 15th century made the question more pressing. Numerous publications over the following decades called for a calendar reform, among them a paper sent to the Vatican by the University of Salamanca in 1515, but the project was not taken up again until the 1540s, and implemented only under Pope Gregory XIII (r. 1572–1585).


CALENDARIVM
GREGORIANVM
PERPETVVM.

Orbi Christiano vniuerso à Gregorio XIII. P. M. propositum. Anno M. D. LXXXII.

GREGORIVS EPISCOPVS
SERVVS SERVORVM DEI
AD PERPETVAM REI MEMORIAM.

First page of the papal bull *Inter gravissimas*

Detail of the pope's tomb by Camillo Rusconi (completed 1723); Antonio Lilio is genuflecting before the pope, presenting his printed calendar.

Preparation

In 1545, the Council of Trent authorized Pope Paul III to reform the calendar, requiring that the date of the vernal equinox be restored to that which it held at the time of the First Council of Nicaea in 325 and that an alteration to the calendar be designed to prevent future drift. This would allow for a more consistent and accurate scheduling of the feast of Easter.

In 1577, a *Compendium* was sent to expert mathematicians outside the reform commission for comments. Some of these experts, including Giambattista Benedetti and Giuseppe Moleto, believed Easter should be computed from the true motions of the sun and moon, rather than using a tabular method, but these recommendations were not adopted.[15] The reform adopted was a modification of a proposal made by the Calabrian doctor Aloysius Lilius (or Lilio).[4]

Lilius's proposal included reducing the number of leap years in four centuries from 100 to 97, by making three out of four centurial years common instead of leap years. He also produced an original and practical scheme for adjusting the epacts of the moon when calculating the annual date of Easter, solving a long-standing obstacle to calendar reform.

Ancient tables provided the sun's mean longitude.[16][17] Christopher Clavius, the architect of the Gregorian calendar, noted that the tables agreed neither on the time when the sun passed through the vernal equinox nor on the length of the mean tropical year. Tycho Brahe also noticed discrepancies.[18][19] The Gregorian leap year rule (97 leap years in 400 years) was put forward by Petrus Pitatus of Verona in 1560. He noted that it is consistent with the tropical year of the Alfonsine tables and with the mean tropical year of Copernicus (*De revolutionibus*) and Reinhold (*Prutenic tables*). The three mean tropical years in Babylonian sexagesimals as the excess over 365 days (the way they would have been extracted from the tables of mean longitude) were 14,33,9,57 (Alphonsine), 14,33,11,12 (Copernicus) and 14,33,9,24 (Reinhold). All values are the same to two places (14:33) and this is also the mean length of the Gregorian year. Thus Pitatus' solution would have commended itself to the astronomers.[20]

Lilius's proposals had two components. Firstly, he proposed a correction to the length of the year. The mean tropical year is 365.24219 days long.[21] As the average length of a Julian year is 365.25 days, the Julian year is almost 11 minutes longer than the mean tropical year. The discrepancy results in a drift of about three days every 400 years. Lilius's proposal resulted in an average year of 365.2425 days (see Accuracy). At the time of Gregory's reform there had already been a drift of 10 days since the Council of Nicaea, resulting in the vernal equinox falling on 10 or 11 March instead of the ecclesiastically fixed date of 21 March, and if unreformed it would drift further. Lilius proposed that the 10-day drift should be corrected by deleting the Julian leap day on each of its ten occurrences over a period of forty years, thereby providing for a gradual return of the equinox to 21 March.

Lilius's work was expanded upon by Christopher Clavius in a closely argued, 800-page volume. He would later defend his and Lilius's work against detractors. Clavius's opinion was that the correction should take place in one move, and it was this advice which prevailed with Gregory.

The second component consisted of an approximation which would provide an accurate yet simple, rule-based calendar. Lilius's formula was a 10-day correction to revert the drift since the Council of Nicaea, and the imposition of a leap day in only 97 years in 400 rather than in 1 year in 4. The proposed rule was that *years divisible by 100 would be leap years only if they were divisible by 400 as well.*

The 19-year cycle used for the lunar calendar was also to be corrected by one day every 300 or 400 years (8 times in 2500 years) along with corrections for the years that are no longer leap years (i.e., 1700, 1800, 1900, 2100, etc.). In fact, a new method for computing the date of Easter was introduced.

When the new calendar was put in use, the error accumulated in the 13 centuries since the Council of Nicaea was corrected by a deletion of 10 days. The Julian calendar day Thursday, 4 October 1582 was followed by the first day of the Gregorian calendar, Friday, 15 October 1582 (the cycle of weekdays was not affected).

Adoption

Although Gregory's reform was enacted in the most solemn of forms available to the Church, the bull had no authority beyond the Catholic Church and the Papal States. The changes that he was proposing were changes to the civil calendar, over which he had no authority. They required adoption by the civil authorities in each country to have legal effect.

The bull *Inter gravissimas* became the law of the Catholic Church in 1582, but it was not recognised by Protestant Churches, Orthodox Churches, and a few others. Consequently, the days on which Easter and related holidays were celebrated by different Christian Churches again diverged.

A month after having decreed the reform, the pope with a brief of 3 April 1582 granted to Antonio Lilio, the brother of Luigi Lilio, the exclusive right to publish the calendar for a period of ten years. The *Lunario Novo secondo la nuova riforma* printed by Vincenzo Accolti, one of the first calendars printed in Rome after the reform, notes at the bottom that it was signed with papal authorization and by Lilio (*Con licentia delli Superiori... et permissu Ant(onii) Lilij*). The papal brief was later revoked, on 20 September 1582, because Antonio Lilio proved unable to keep up with the demand for copies.[22]

On 29 September 1582, Philip II of Spain decreed the change from the Julian to the Gregorian calendar.[23] This affected much of Roman Catholic Europe, as Philip was at the time ruler over Spain and Portugal as well as much of Italy. In these territories, as well as in the Polish–Lithuanian Commonwealth (ruled by Anna Jagiellon) and in the Papal States, the new calendar was implemented on the date specified by the bull, with Julian Thursday, 4 October 1582, being followed by Gregorian Friday, 15 October 1582. The Spanish and Portuguese colonies followed somewhat later *de facto* because of delay in communication.[24]

Many Protestant countries initially objected to adopting a Catholic innovation; some Protestants feared the new calendar was part of a plot to return them to the Catholic fold. For example, the British could not bring themselves to adopt the Catholic system explicitly: the Annexe to their Calendar (New Style) Act 1750 established a computation for the date of Easter that achieved the same result as Gregory's rules, without actually referring to him.[25]

Britain and the British Empire (including the eastern part of what is now the United States) adopted the Gregorian calendar in 1752. Sweden followed in 1753.

Prior to 1917, Turkey used the lunar Islamic calendar with the Hegira era for general purposes and the Julian calendar for fiscal purposes. The start of the fiscal year was eventually fixed at 1 March and the year number was roughly equivalent to the Hegira year (see Rumi calendar). As the solar year is longer than the lunar year this originally entailed the use of "escape years" every so often when the number of the fiscal year would jump. From 1 March 1917 the fiscal year became Gregorian, rather than Julian. On 1 January 1926 the use of the Gregorian calendar was extended to include use for general purposes and the number of the year became the same as in most other countries.

Adoption of the Gregorian Calendar

1500	1600	1700	1800	1900
1582: Spain, Portugal, France, Poland, Italy, Catholic Low Countries, Luxemburg, and colonies **1584**: Kingdom of Bohemia	**1610**: Prussia **1648**: Alsace **1682**: Strasbourg	**1700**: 'Germany', Swiss Cantons, Protestant Low Countries, Norway, Denmark **1752**: Great Britain and colonies **1753**: Sweden and Finland	**1873**: Japan **1875**: Egypt **1896**: Korea	**1912**: China, Albania **1915**: Latvia, Lithuania **1916**: Bulgaria **1918**: USSR, Estonia **1919**: Romania, Yugoslavia[Note 8] **1923**: Greece **1926**: Turkey

Difference between Gregorian and Julian calendar dates

Since the introduction of the Gregorian calendar, the difference between Gregorian and Julian calendar dates has increased by three days every four centuries (all date ranges are inclusive):

Conversion from Julian to Gregorian dates.[26]

Gregorian range	Julian range	Difference
From 15 October 1582 to 28 February 1700	From 5 October 1582 to 18 February 1700	10 days
From 1 March 1700 to 28 February 1800	From 19 February 1700 to 17 February 1800	11 days
From 1 March 1800 to 28 February 1900	From 18 February 1800 to 16 February 1900	12 days
From 1 March 1900 to 28 February 2100	From 17 February 1900 to 15 February 2100	13 days
From 1 March 2100 to 28 February 2200	From 16 February 2100 to 14 February 2200	14 days

This section always places the intercalary day on 29 February even though it was always obtained by doubling 24 February (the *bissextum* (twice sixth) or bissextile day) until the late Middle Ages. The Gregorian calendar is proleptic before 1582 (assumed to exist before 1582).

The following equation gives the number of days (actually, dates) that the Gregorian calendar is ahead of the Julian calendar, called the *secular difference* between the two calendars. A negative difference means the Julian calendar is ahead of the Gregorian calendar.[27]

$$D = \lfloor Y/100 \rfloor - \lfloor Y/400 \rfloor - 2$$

where D is the secular difference and Y is the year using astronomical year numbering, that is, use (year BC) − 1 for BC years. $\lfloor x \rfloor$ means that if the result of the division is not an integer it is rounded down to the nearest integer. Thus during the 1900s, 1900/400 = 4, while during the −500s, −500/400 = −2.

The general rule, in years which are leap years in the Julian calendar but not the Gregorian, is as follows:

Up to 28 February in the calendar you are converting *from* add one day less or subtract one day more than the calculated value. Remember to give February the appropriate number of days for the calendar you are converting *into*. When you are subtracting days to move from Julian to Gregorian be careful, when calculating the Gregorian equivalent of 29 February (Julian), to remember that 29 February is discounted. Thus if the calculated value is −4 the Gregorian equivalent of this date is 24 February.[28][29]

Beginning of the year

The year used in dates during the Roman Republic and the Roman Empire was the consular year, which began on the day when consuls first entered office—probably 1 May before 222 BC, 15 March from 222 BC and 1 January from 153 BC.[36] The Julian calendar, which began in 45 BC, continued to use 1 January as the first day of the new year. Even though the year used for dates changed, the civil year always displayed its months in the order January to December from the Roman Republican period until the present.

During the Middle Ages, under the influence of the Catholic Church, many Western European countries moved the start of the year to one of several important Christian festivals—25 December (supposed Nativity of Jesus), 25 March (Annunciation), or Easter (France),[37] while the Byzantine Empire began its year on 1 September and Russia did so on 1 March until 1492 when the new year was moved to 1 September.[38]

In common usage, 1 January was regarded as New Year's Day and celebrated as such,[39] but from the 12th century until 1751 the legal year in England began on 25 March (Lady Day).[40] So, for example, the Parliamentary record lists the execution of Charles I on 30 January as occurring in 1648 (as the year did not end until 24 March),[41] although later histories adjust the start of the year to 1 January and record the execution as occurring in 1649.[42]

Most Western European countries changed the start of the year to 1 January before they adopted the Gregorian calendar. For example, Scotland changed the start of the Scottish New Year to 1 January in 1600 (this means that 1599 was a short year). England, Ireland and the British colonies changed

Country	Start numbered year on 1 January	Adoption of Gregorian calendar
Denmark	Gradual change from 13th to 16th centuries[30]	1700
Venice	1522	1582
Holy Roman Empire (Catholic states)	1544	1583
Spain, Poland, Portugal	1556	1582
Holy Roman Empire (Protestant states)	1559	1700
Sweden	1559	1753
France	1564[31]	1582[n 1]
Southern Netherlands	1576[32]	1582
Lorraine	1579	1682
Dutch Republic	1583	1582
Scotland	1600[33][34]	1752
Russia	1700[35]	1918
Tuscany	1721	1750
Great Britain and the British Empire except Scotland	1752[33]	1752

the start of the year to 1 January in 1752 (so 1751 was a short year with only 282 days) though in England the start of the tax year remained at 25 March (O.S.), 5 April (N.S.) till 1800, when it moved to 6 April. Later in 1752 in September the Gregorian calendar was introduced throughout Britain and the British colonies (see the section Adoption). These two reforms were implemented by the Calendar (New Style) Act 1750.[43]

In some countries, an official decree or law specified that the start of the year should be 1 January. For such countries a specific year when a 1 January-year became the norm can be identified. In other countries the customs varied, and the start of the year moved back and forth as fashion and influence from other countries dictated various customs.

Neither the papal bull nor its attached canons explicitly fix such a date, though it is implied by two tables of saint's days, one labelled 1582 which ends on 31 December, and another for any full year that begins on 1 January. It also specifies its epact relative to 1 January, in contrast with the Julian calendar, which specified it relative to 22 March. The old date was derived from the Greek system: the earlier *Supputatio Romana* specified it relative to 1 January.

1. In 1793 France abandoned the Gregorian calendar in favour of the French Republican Calendar. This change was reverted in 1805.

Dual dating

During the period between 1582, when the first countries adopted the Gregorian calendar, and 1923, when the last European country adopted it, it was often necessary to indicate the date of some event in both the Julian calendar and in the Gregorian calendar, for example, "10/21 February 1750/51", where the dual year accounts for some countries already beginning their numbered year on 1 January while others were still using some other date. Even before 1582, the year sometimes had to be double dated because of the different beginnings of the year in various countries. Woolley, writing in his biography of John Dee (1527–1608/9), notes that immediately after 1582 English letter writers "customarily" used "two dates" on their letters, one OS and one NS.[44]

Old Style and New Style dates

"Old Style" (OS) and "New Style" (NS) are sometimes added to dates to identify which calendar reference system is used for the date given. In Britain and its Colonies, where the Calendar Act of 1750 altered the start of the year,[Note 9] and also aligned the British calendar with the Gregorian calendar, there is some confusion as to what these terms mean. They can indicate that the start of the Julian year has been adjusted to start on 1 January (NS) even though contemporary documents use a different start of year (OS); or to indicate that a date conforms to the Julian calendar (OS), formerly in use in many countries, rather than the Gregorian calendar (NS).[42][45][46][47]

Proleptic Gregorian calendar

Extending the Gregorian calendar backwards to dates preceding its official introduction produces a proleptic calendar, which should be used with some caution. For ordinary purposes, the dates of events occurring prior to 15 October 1582 are generally shown as they appeared in the Julian calendar, with the year starting on 1 January, and no conversion to their Gregorian equivalents. For example, the Battle of Agincourt is universally considered to have been fought on 25 October 1415

which is Saint Crispin's Day.

Usually, the mapping of new dates onto old dates with a start of year adjustment works well with little confusion for events that happened before the introduction of the Gregorian calendar. But for the period between the first introduction of the Gregorian calendar on 15 October 1582 and its introduction in Britain on 14 September 1752, there can be considerable confusion between events in continental western Europe and in British domains in English language histories.

Events in continental western Europe are usually reported in English language histories as happening under the Gregorian calendar. For example, the Battle of Blenheim is always given as 13 August 1704. Confusion occurs when an event affects both. For example, William III of England arrived at Brixham in England on 5 November 1688 (Julian calendar), after setting sail from the Netherlands on 11 November 1688 (Gregorian calendar).

Shakespeare and Cervantes seemingly died on exactly the same date (23 April 1616), but Cervantes predeceased Shakespeare by ten days in real time (as Spain used the Gregorian calendar, but Britain used the Julian calendar). This coincidence encouraged UNESCO to make 23 April the World Book and Copyright Day.

Astronomers avoid this ambiguity by the use of the Julian day number.

For dates before the year 1, unlike the proleptic Gregorian calendar used in the international standard ISO 8601, the traditional proleptic Gregorian calendar (like the Julian calendar) does not have a year 0 and instead uses the ordinal numbers 1, 2, ... both for years AD and BC. Thus the traditional time line is 2 BC, 1 BC, AD 1, and AD 2. ISO 8601 uses astronomical year numbering which includes a year 0 and negative numbers before it. Thus the ISO 8601 time line is –0001, 0000, 0001, and 0002.

Months

The Gregorian calendar continued to employ the Julian months, which have Latinate names and irregular numbers of days:

- January (31 days), from Latin *mēnsis Iānuārius*, "Month of Janus",[48] the Roman god of gates, doorways, beginnings and endings
- February (28 days in common and 29 in leap years), from Latin *mēnsis Februārius*, "Month of the Februa", the Roman festival of purgation and purification,[49][50] cognate with fever,[49] the Etruscan death god Februus ("Purifier"), and the PIE word for sulfur[49]
- March (31 days), from Latin *mēnsis Mārtius*, "Month of Mars",[51] the Roman war god[50]
- April (30 days), from Latin *mēnsis Aprīlis*, of uncertain meaning[52] but usually derived from some form of the verb *aperire* ("to open")[53] or the name of the goddess Aphrodite[50][57]
- May (31 days), from Latin *mēnsis Māius*, "Month of Maia",[58] a Roman vegetation goddess[50] whose name is cognate with Latin *magnus* ("great")[58] and English *major*
- June (30 days), from Latin *mēnsis Iūnius*, "Month of Juno",[59] the Roman goddess of marriage, childbirth, and rule[50]
- July (31 days), from Latin *mēnsis Iūlius*, "Month of Julius Caesar", the month of Caesar's birth, instituted in 44 BC[60] as part of his calendrical reforms[50]
- August (31 days), from Latin *mēnsis Augustus*, "Month of Augustus", instituted by Augustus in 8 BC in agreement with July and from the occurrence during the month of several important events during his rise to power[61]
- September (30 days), from Latin *mēnsis september*, "seventh month", from its position in the Roman calendar before 153 BC[62]
- October (31 days), from Latin *mēnsis octōber*, "eighth month",[63] from its position in the Roman calendar before 153 BC[62]

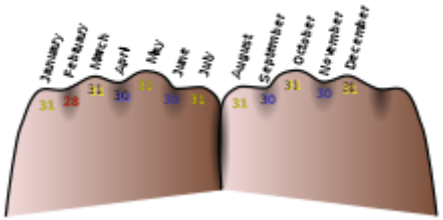
- November (30 days), from Latin *mēnsis november*, "ninth month",[64] from its position in the Roman calendar before 153 BC[62]
- December (31 days), from Latin *mēnsis december*, "tenth month",[65] from its position in the Roman calendar before 153 BC[62]

Europeans sometimes attempt to remember the number of days in each month by memorizing some form of the traditional verse "Thirty Days Hath September". It appears in Latin,[66][67] Italian,[68] and French,[69] and belongs to a broad oral tradition but the earliest currently attested form of the poem is the English marginalia inserted into a calendar of saints c. 1425:[70][71][72]

> Thirti dayes hath novembir
> April june and Septembir.
> Of xxviij is but oon
> And alle the remenaunt xxx and j[71]

> Thirty days have November,
> April, June, and September.
> Of 28 is but one
> And all the remnant 30 and 1.

Variations appeared in *Mother Goose* and continue to be taught at schools. The unhelpfulness of such involved mnemonics has been parodied as "Thirty days hath September / But all the rest I can't remember"[73] but it has also been called "probably the only sixteenth-century poem most ordinary citizens know by heart".[74] A common nonverbal alternative is the knuckle mnemonic, considering the knuckles of one's hands as months with 31 days and the lower spaces between them as the months with fewer days. Using two hands, one may start from either pinkie knuckle as January and count across, omitting the space between the index knuckles (July and August). The same procedure can be done using the knuckles of a single hand, returning from the last (July) to the first (August) and continuing through. A similar mnemonic is to move up a piano keyboard in semitones from an F key, taking the white keys as the longer months and the black keys as the shorter ones.



The knuckle mnemonic for the days of the months of the year

Weeks

In conjunction with the system of months there is a system of weeks. A physical or electronic calendar provides conversion from a given date to the weekday, and shows multiple dates for a given weekday and month. Calculating the day of the week is not very simple, because of the irregularities in the Gregorian system. When the Gregorian calendar was adopted by each country, the weekly cycle continued uninterrupted. For example, in the case of the few countries that adopted the reformed calendar on the date proposed by Gregory XIII for the calendar's adoption, Friday, 15 October 1582, the preceding date was Thursday, 4 October 1582 (Julian calendar).

Opinions vary about the numbering of the days of the week. ISO 8601, in common use worldwide, starts with Monday=1; printed monthly calendar grids often list Mondays in the first (left) column of dates and Sundays in the last. Software often starts with Sunday=0, which places Sundays in the left column of a monthly calendar page.

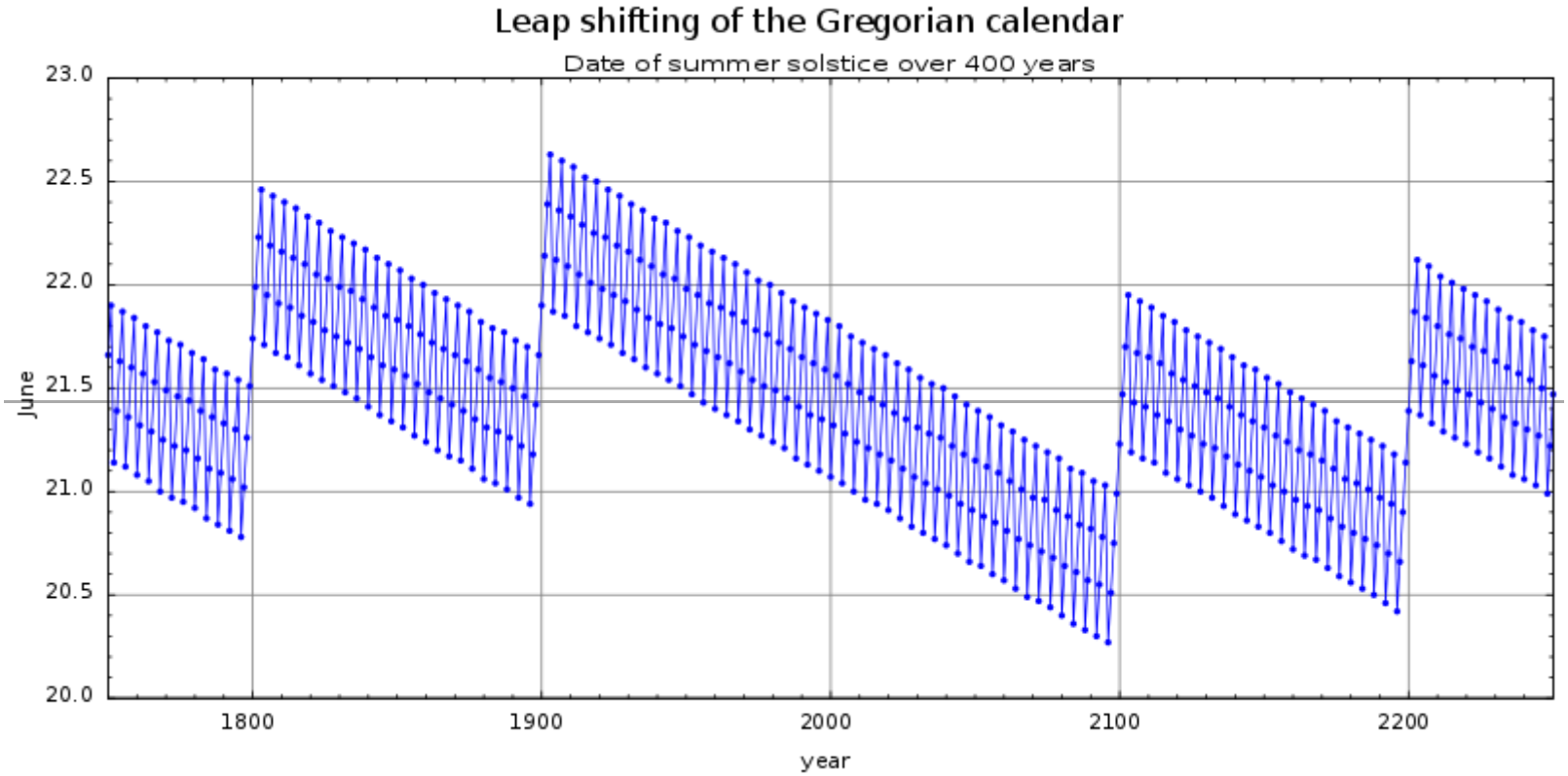
Accuracy

The Gregorian calendar improves the approximation made by the Julian calendar by skipping three Julian leap days in every 400 years, giving an average year of 365.2425 mean solar days long.[75] This approximation has an error of about one day per 3,030 years[76] with respect to the current value of the mean tropical year. However, because of the precession of the equinoxes, which is not constant, and the movement of the perihelion (which affects the Earth's orbital speed) the error with respect to the *astronomical* vernal equinox is variable; using the average interval between vernal equinoxes near 2000 of 365.24237 days[77] implies an error closer to 1 day every 7,700 years. By any criterion, the Gregorian calendar is substantially more accurate than the 1 day in 128 years error of the Julian calendar (average year 365.25 days).

In the 19th century, Sir John Herschel proposed a modification to the Gregorian calendar with 969 leap days every 4000 years, instead of 970 leap days that the Gregorian calendar would insert over the same period.[78] This would reduce the average year to 365.24225 days. Herschel's proposal would make the year 4000, and multiples thereof, common instead of leap. While this modification has often been proposed since, it has never been officially adopted.[79]

On time scales of thousands of years, the Gregorian calendar falls behind the astronomical seasons because the slowing down of the Earth's rotation makes each day slightly longer over time (see tidal acceleration and leap second) while the year maintains a more uniform duration.

Calendar seasonal error



This image shows the difference between the Gregorian calendar and the astronomical seasons.

The *y*-axis is the date in June and the *x*-axis is Gregorian calendar years.

Each point is the date and time of the June solstice in that particular year. The error shifts by about a quarter of a day per year. Centurial years are ordinary years, unless they are divisible by 400, in which case they are leap years. This causes a correction in the years 1700, 1800, 1900, 2100, 2200, and 2300.

For instance, these corrections cause 23 December 1903 to be the latest December solstice, and 20 December 2096 to be the earliest solstice—about 2.35 days of variation compared with the seasonal event.

Proposed reforms

The following are proposed reforms of the Gregorian calendar:

- Holocene calendar

- International Fixed Calendar (also called the *International Perpetual calendar*)
- World Calendar
- World Season Calendar
- Leap week calendars
  - Pax Calendar
  - Symmetry454
  - Hanke–Henry Permanent Calendar

See also

- Calendar (New Style) Act 1750
- Calendar reform
- Conversion between Julian and Gregorian calendars
- Doomsday rule
- French revolutionary calendar
- Hebrew calendar
- Islamic calendar
- Inter gravissimas in English – Wikisource
- Julian day calculation
- History of calendars
- List of adoption dates of the Gregorian calendar per country
- List of calendars
- Old Calendarists
  - Greek Old Calendarists
- Revised Julian calendar (Milanković) – used in Eastern Orthodoxy

Precursors of the Gregorian reform

- Johannes de Sacrobosco, *De Anni Ratione* ("On reckoning the years"), c. 1235
- Roger Bacon, *Opus Majus* ("Greater Work"), c. 1267

Notes

1. The international standard for the representation of dates and times, ISO 8601, uses the Gregorian calendar. Section 3.2.1.

2. In Great Britain and its colonies, "Old Style" typically implies that the date is given in the Julian calendar with the year beginning on 25 March, whereas "New Style" implies use of the Gregorian calendar with years beginning 1 January.
3. The first known occurrence of *Common Era* in English dates to 1708. Years before the beginning of the era are abbreviated in English as either BC for "Before Christ", or as BCE for "Before the Common Era". Two era names occur within the bull *Inter gravissimas* itself, *anno Incarnationis dominicæ* ("in the year of the Incarnation of the Lord") for the year it was signed, and *anno à Nativitate Domini nostri Jesu Christi* ("in the year from the Nativity of our Lord Jesus Christ") for the year it was printed.[8]
4. The cycle described applies to the solar, or civil, calendar. If one also considers the ecclesiastical lunar rules, the lunisolar Easter *computus* cycle repeats only after 5,700,000 years of 2,081,882,250 days in 70,499,183 lunar months, based on an assumed mean lunar month of 29 days 12 hours 44 minutes 2 $\frac{49928114}{70499183}$ seconds.
   (Seidelmann (1992), p. 582) [To properly function as an Easter *computus*, this lunisolar cycle must have the same mean year as the Gregorian solar cycle, and indeed that is exactly the case.]
5. The extreme length of the Gregorian Easter *computus* is due to its being the product of the 19-year Metonic cycle, the thirty different possible values of the epact, and the least common multiple (10,000) of the 400-year and 2,500-year solar and lunar correction cycles.[11]
6. The same result is obtained by summing the fractional parts implied by the rule: $365 + \frac{1}{4} - \frac{1}{100} + \frac{1}{400} = 365 + 0.25 - 0.01 + 0.0025 = 365.2425$
7. The last major Christian region to accept the Alexandrian rules was the Carolingian Empire (most of Western Europe) during 780–800. The last monastery in England to accept the Alexandrian rules did so in 931, and a few churches in southwest Asia beyond the eastern border of the Byzantine Empire continued to use rules that differed slightly, causing four dates for Easter to differ every 532 years.
8. 1919 in the regions comprising the former Kingdoms of Serbia and Montenegro (present-day Kosovo, Montenegro, Serbia and Macedonia). The western and northern regions of what became Yugoslavia were already using the Gregorian calendar. For example, most of Slovenia adopted the Gregorian calendar at the same time as Austria in 1583. Coastal Croatia, which was at the time ruled by Venice, adopted the Gregorian calendar in 1582. Inland Croatia, ruled by the Habsburgs, adopted it in 1587 along with Hungary. The Gregorian calendar was used in Bosnia and Herzegovina since the 16th century by the Catholic population and was formally adopted for government use in 1878 following occupation by Austria-Hungary.
9. In Scotland the legal start of year had been moved to 1 January in 1600 (Mike Spathaky. Old Style New Style dates and the change to the Gregorian calendar (http://www.cree.name/genuki/dates.htm)).

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3. See Wikisource English translation of the (Latin) 1582 papal bull *Inter gravissimas*.
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9. Richards, p. 101
10. Clause 3.2.1 ISO 8601
11. Walker (1945), p.218.
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External links

- Gregorian calendar (http://www.bbc.co.uk/programmes/p00548m9) on *In Our Time* at the BBC.
- Calendar Converter (http://www.fourmilab.ch/documents/calendar/)
- Inter Gravissimas (Latin and French plus English) (http://www.bluewaterarts.com/calendar/NewInterGravissimas.htm)
- History of Gregorian Calendar (http://webexhibits.org/calendars/year-history.html)
- The Perpetual Calendar Gregorian Calendar adoption dates for many countries. (http://www.norbyhus.dk/calendar.php)
- World records for mentally calculating the day of the week in the Gregorian Calendar (http://www.recordholders.org/en/records/dates.html)
- The Calendar FAQ (http://www.tondering.dk/claus/calendar.html) – Frequently Asked Questions about Calendars
- Today's date (Gregorian) in over 400 more-or-less obscure foreign languages (http://www.curiousnotions.com/todays-date.asp)