

The Gregorian Calendar

September 2002 is the 250th anniversary of Britain's adoption of the Gregorian Calendar. In September 1752, people in Britain retired to bed on Wednesday September 2, and woke up on Thursday September 14. Britain had changed from the Julian calendar to the Gregorian (just about 170 years later than most other countries in western Europe!) In many places there was an outcry against "the stolen 11 days". What was all this about and how did it happen?

Over the millennia calendars have been devised to group together and name (label) individual days to help people identify and anticipate important religious, legal, fiscal (tax), and commercial events, seasons, and lunar phases.

Complications arise because the three different natural time cycles (day, month, and year) don't align with each other at all –

and year. It was people's expectation that months and years should contain whole numbers of days.

Calendars were intended to group days in blocks of whole numbers making up months (as close as possible to a lunar month) and years (as close as possible to the true solar year). The original idea was to group and name the days so that events which repeated each month or year would fall again on the same named day – e.g. the same moon phase repeating on the same day in each month group, and the same season (solstice or equinox) starting on the same day in each year group.

The calendar ideal could never be realised because lunar months and solar years are not made up of whole numbers of days, and there isn't a whole number of lunar months in a solar year – a precise 12-month lunar year has 354.3672 days compared to the true solar year of 365.242199 days.

All calendars therefore suffer from 'drift' – repeating events (eg the solstices & equinoxes) eventually don't fall on the same day in the next cycle but happen progressively earlier or later than expected by the calendar.

As a result, over the millennia each culture has had to choose between the lunar and solar cycles as the primary calendar basis. Some (eg the Islamic calendar) stuck to the lunar cycle and have no connection with the solar year. Others (eg our own based on the later Roman calendar) have tried to use the solar annual cycle and retain some month groupings more as a convenience than to align with true lunar months. The Jewish Calendar combines both. The story of calendar development has been about better and better measurements of the natural time cycles, and progressive adjustment to keep alignment with the true solar year by adding or deleting days from the calendar periodically (called intercalation).

The Day – the time for one rotation of the Earth in relation to the Sun. (Divided into hours, minutes & seconds which are artefacts – invented by man with no special natural basis. The mean solar day is 24 hours — 3 minutes 56 seconds longer than the stellar, or sidereal, day.)

The Lunar (or Synodic) Month – an awkward **29.5306 days** by modern instruments. The time between one new moon and the next. The phases of the Moon are very prominent and relatively frequent and have always been powerful influences on people's thinking. Many ancient cultures first devised calendars based on lunar months.

The Year – **365.242199 days** (mean tropical year) The time for one orbit of the Earth around the Sun. The significance of the year and seasons, especially to agriculture (planting, harvesting, Nile flood etc), was so important that most cultures set out to devise calendars based on the solar year. Many have tried to incorporate both the solar year and lunar month.

19 tropical years is almost 235 (234.997) synodic months — every 19 years the phases of the moon fall on the same dates. 19 years is called a **Metonic cycle** (after Meton of Athens 5th Century BC)

Of course, ancient peoples didn't know the modern values for lunar months and solar years. Early astronomy developed in part as people invented better means to count the number of days in a month

Sources:

The Calendar by David Duncan. London, Fourth Estate 1998. PB 1999.

Internet Links:

<http://www.rog.nmm.ac.uk/leaflets/calendar/calendar.html>

<http://www.rog.nmm.ac.uk/education/numeracy/Numtable.html>

<http://webexhibits.org/calendars/year.html>

http://serendipity.magnet.ch/hermetic/cal_stud/dst02.htm

Roman Calendars

Romulus' Calendar

By legend, created by Romulus the mythic first king of Rome. Counted from the year of foundation of the City (753 BC), year 1 AUC *ab urbe condita*.

Lunar based. Composed of 10 months (not 12) for a total of **304** days, plus an unnumbered and unnamed winter period

Month	Name	
1	Martis	God of War
2	Aprilis	after Aphrodite or <i>aperire</i> (to open)
3	Maius	local Italian goddess
4	Junius	Queen of the Roman gods
5	Quintilis	Fifth month
6	Sextilis	Sixth
7	September	Seventh
8	October	Eighth
9	November	Ninth
10	December	Tenth month

Day Names (no weeks)

Named day markers fall at the beginning of the month (**kalends**), on the 5th (or 7th) day (**nones** – ninth before ides) and in the middle (**ides** – 13th of the month, except 15th of March, May, July, and October). Example – first half of March:

March 1	Kalends Martius 1 st
March 2	VI nones (5 days before nones)
March 3	V nones (4 days before nones)
March 4	IV nones
March 5	III nones
March 6	Pridie nones (day before nones)
March 7	Nones
March 8	VIII ides (7 days before ides)
March 9	VII ides
March 10	VI ides
March 11	V ides
March 12	IV ides
March 13	III ides
March 14	Pridie ides
March 15	Ides.

King Numa Pompilius around 700 BC

Added *Januarius* (after the god Janus) and *Februarius* (after Februa, the purification festival) following December for **355** days. This was badly flawed and needed days and months intercalated to keep it aligned with the seasons. Rome eventually adopted the Greek system that inserted intercalary months every 8 years, coming roughly in line with a 365 day year. The system was so confusing that the priests forgot to insert months and the calendar slipped back and forth against the solar year.

Julian Calendar - 46 BC

Legend has it that while he was in Egypt, Julius Caesar met Cleopatra and discovered Ptolemy III's Calendar (from 238 BC) of **365¼ days** average – **365 days with a leap year of 366 every fourth year.**

By 47 BC the old calendar had drifted 80 days off the solar year. Julius introduced the new calendar in 46 BC (708 AUC) – that year had 445 days to **realign the vernal equinox with its traditional date -- March 25.**

Julius moved the start of the year from March to January nearer the winter solstice.

The lengths of months were reorganised to bring the year to 365 days. The calendar was arranged in 12 months of alternating 31 and 30 days, except February that had 29 and 30 in a leap year.

In 44 BC the Senate renamed *Quintilius* to **Julius** in his honour

Augustus Caesar — 8 BC

In 8 BC (allegedly) the Senate renamed *Sextilius* to **Augustus** in honour of Caesar. Augustus wanted his month to have the maximum 31 days so he pinched a day from February and switched round the number of days in September, October, November, & December. (this story is probably a 14th century fabrication).

The Julian Year of 365.25 days overestimates the mean tropical year by 10 minutes 48 seconds — an error of 1 day in about 128 years.

Month	Julius 44 BC	Augustus 8 BC
Januarius	31 days	31 days
Februarius	29; 30 in leap years	28; 29 in leap years
Martius	31	31
Aprilis	30	30
Maius	31	31
Junius	30	30
Quintilius	<i>Julius</i> 31	31
Sextilius	30	<i>Augustus</i> 31
September	31	30
October	30	31
November	31	30
December	30	31

Constantine the Great

First Christian Emperor. Founder of eastern capital at Byzantium (Constantinople)

321 CE (AD).
Establishes Sunday as a holy day, the first day of a seven day week (Seven days based on old testament text and also seven 'planets')

Gives official recognition to Christian holidays such as Christmas, with fixed dates.

Establishes rules for the date of **Easter** as part of a centralisation of church authority. Easter doesn't have a fixed date but moves around – hence 'moveable feast'.

Constantine's **Council of Nicaea** (modern Iznik, Turkey) 325 CE, agrees Easter will fall on the first Sunday after the first full moon after the vernal equinox, but never at the beginning of the Jewish Passover.

In the absence of good astronomy, the **Vernal equinox is arbitrarily set for March 21**, but the Council fails to correct the error in the Julian calendar – Easter pinned to a fixed equinox of March 21 will drift backwards with the rest of the calendar.

<i>Planet</i>	<i>Ancient Planet-Gods</i>		<i>Modern-day Names</i>	
	<i>Roman</i>	<i>Anglo-Saxon</i>	<i>English</i>	<i>French</i>
Sun	Sol	Sun	Sunday	Dimanche
Moon	Luna	Moon	Monday	Lundi
Mars	Mars	Tiw	Tuesday	Mardi
Mercury	Mercurius	Woden	Wednesday	Mercredi
Jupiter	Jupiter	Thor	Thursday	Jeudi
Venus	Venus	Freya	Friday	Vendredi
Saturn	Saturnus	Saturn	Saturday	Samedi

The Dark Ages & Islam

During the European Dark Ages calendar science is only studied by monks concerned about the celebration of Easter – the “*Computus*”.

From about 630 CE, astronomy and calendar science are developed by the Islamic cultures in the Middle-east, North Africa and Spain. Islam preserves many ancient texts from Greece and Rome. The Koran requires Muslims to observe the Islamic calendar especially the fast of Ramadan (the 9th month).

The Islamic (or Hijri) Calendar is purely lunar, based on 12 synodic months (12 x 29.53 = 354.36 days) so it is consistently shorter than the tropical year and always shifts with respect to the Gregorian. Year 1 AH (*anno hegirae* – year of the Migration) began in 622 CE when Mohammed fled Mecca for Medina – the *Hijra*.

Each month starts when the lunar crescent is first observed (by eye) after a new moon. Actual visibility of the crescent is very difficult to predict because of weather conditions etc, so it's difficult to give advance information about when a new month will start.

Dionysius Exiguus (c. 500 – 560 CE)

Dionysius straightens out the Easter calculation for the Roman church.

Invents **anno Domini** (AD) system of dating (now referred to as common era CE). Calculates Christ born 531 years earlier which he designates AD 1 (concept of zero had not been invented).

Unfortunately, Dionysius' calculation was wrong – Christ must have been born between 7 BC and 4 BC.

AD system appears in Britain by seventh century, and Gaul in eighth, but not until 1300 in parts of Spain.

365.242199

The Romans had no way to represent Zero or the Decimal Point

Zero and positional notation came to us from India via the Islamic cultures in Spain.

The Gregorian Reform

1345 CE – Pope Clement VI at Avignon invites a commission on calendar reform. Jean de Meurs from Paris proposes reforms to the lunar calendar to correct drift away from the 19 year cycle.

1347 CE – Outbreak of the Black Death. Calendar reforms are forgotten.

1500 CE -- the calendar has drifted away from the equinoxes by over 12 days since Caesar and 9 days since the Council of Nicaea. The Fifth Lateran Council 1512 – 1517, considers some questions about the proper date to celebrate Easter.

1514 CE — Pope Leo X invites the Dutch astronomer, bishop Paul of Middelburg, to lead a commission on calendar reform. Leo circulates proposals for reform but they are mostly ignored -- four letters to Henry VIII survive in British archives, all unanswered. One answer, though, is received from **Nicolaus Copernicus**. Included in his later work is a better measurement of the tropical year – 365.2425 days. *De revolutionibus* is finally published in the year of his death 1543.

1517 CE – Martin Luther tacks his document to the door of the cathedral at Wittenburg. The Church has bigger issues to worry about. Calendar reform dies out.

1572 CE — Ugo Buoncompagni (Pius IV’s deputy at the Council of Trent 1545 – 1563 focussed on suppressing Protestantism and restoring authority of the church) is elected **Pope Gregory XIII** May 14, 1572; sets up new calendar commission mid 1570s. Members include **Christopher Clavius**.

Commission uses calendar proposals developed by **Aloysius Lilius** (Luigi Lilio). Lilius dies in 1576 but his proposals are presented by his brother Antonio.

Lilius bases his analysis on the mean tropical year from the Alfonsine Tables (365d 5h 49m 16s) – the gap against the Julian year is 3 days gained every 402 years. Lilius therefore rounds off and proposes the 400 year leap-year rule which drops 3 days from the calendar every 400 years:

Century years (xx00) are only leap-years if divisible by 400.

Lilius also proposes corrections to the Lunar calendar (needed to determine Easter) which runs roughly an hour and a half behind the 19 year cycle – by 1570 this amounted to an error of 4 days. Proposal drops 1 day from the lunar calendar every 300 years seven times, plus an additional eighth day after 400 years.

Clavius, Copernicus, and Tycho get craters on the moon, but Gregory and Lilius don’t.

1582 CE — After a good deal of acrimonious consultation, **Pope Gregory XIII** signs the bull *Inter gravissimas* on February 24, 1582. Takes effect in October 1582. **To realign the Spring Equinox to March 21, 10 days are dropped from October.** October 4 is followed by October 15, 1582.

Adoption in Britain

In 1582 John Dee advises Elizabeth to adopt the reform on scientific grounds, but Archbishop Grindal opposes change. With the threat of the Armada from Spain in 1588, calendar reform is dropped.

In 1750 George Parker addresses the Royal Society on reform and Philip Stanhope, earl of Chesterfield, takes up the call for change. Stanhope campaigns in the popular press. He introduces a bill, which is passed on May 17, 1751 and approved by King George II.

In **September 1752** the reform comes into effect in Great Britain and her colonies, including North America. **11 days are dropped** (1700 was a Julian leap-year, but not a Gregorian) and September 2 is followed by September 14. The official start of the civic year is moved to January 1 from March 25.

Mobs collected in the streets and shouted, “Give us back our eleven days”. In Bristol, riots over reform ended up with people killed. In the City of London, bankers refused to pay taxes on the usual date of March 25, 1753. They waited the extra 11 days and paid on April 5, which remains tax day in Britain today.

Adoption of the reform is very patchy

Italy, Spain and Portugal make the deadline. France and the Netherlands wait until the end of 1582, some parts skipped Christmas!

Each German Princely State (parts of the Holy Roman Empire) decide independently.

Protestant states including England, reject the reform. Protestants in Germany and Denmark adopt the reform in 1700 but calculate Easter differently until 1775. Sweden applies an entirely unique correction and so remains different to everyone else until 1753.

The Eastern Orthodox Church refuses to change until 1923 with some die-hards waiting until 1968. Russia changes the civic calendar in 1940 but the churches in Jerusalem, Serbia, and Russia retain the Julian calendar.