

Introduction

It's the year 2000. We stand at the dawn of a new century, a new millennium. We can't even begin to imagine what the next thousand years will bring, but if the last thousand years are any guide, the third millennium will hold wonders.

But wait a moment, and ask yourself: why 2000? Why is *this* year so special? And why are we celebrating its birth on January 1st?

Our lives are bound up with the calendar. We use it to plan our future: the annual round of work, meetings, appointments, holidays, birthdays and all of the other events in life. We write them in our diaries so that we won't forget.

Our diaries also tell us of the other events of the coming year: public holidays, religious festivals, weekends, the waxing and waning of the Moon.

The calendar helps us to look back, too. The date of our birth is our personal milestone in the calendar. The historian looks further - to 1945 or 1812 or 1066. They seem to be just numbers, but we know instinctively that they are more than that. Each event, public or personal, great or small, has a day and a month and a year which fixes its place in time.

We take the calendar for granted because it's always been there, day following day, month following month, year following year. We know that it has rules - every fourth year is a leap-year and so we add an extra day to February. But the lengths of the months are irregular, some 31 days, other 30 and poor February only 28 days in three years out of four. Easter seems to move at random. The days of the week provide some kind of regularity, but why do we have seven, and why are they named after a mixture of planets and Norse gods? And why do the British pay their taxes on April 5th?

Our calendar can trace its roots back over 6000 years to ancient Egypt. Its story features Julius Caesar, the Council of Nicaea (which gave us the Nicene Creed), a small Russian monk called Denis, the Venerable Bede and Pope Gregory XIII.

Squaring the Circle

The lives of our ancestors were governed by the cycle of night and day, the waxing and waning of the Moon and the passage of the seasons.

Thus the story of the calendar begins with astronomy, with the Earth, the Sun and the Moon. To be precise, it begins with the length of the day, the year and the lunar month, and the fact that neither the year nor the lunar month is an exact number of days, nor the year an exact number of lunar months.

The cycle of the seasons - Spring, Summer, Autumn, Winter, and Spring once more - is known to astronomers as the *tropical year* and it can be measured very precisely. It is 365.2421896698 days long, although it is gradually getting shorter by about half a second per century.

The lunar month is measured by the phases of the Moon - New Moon, First Quarter, Full Moon, Last Quarter, and New Moon again. It is 29.5305888531 days long, but getting longer by a little less than a fiftieth of a second per century.

There are 12.36826639275 lunar months in a tropical year.

The history of the calendar is largely about the attempts of astronomers, priests and mathematicians to force the tropical year and the lunar month to fit into a scheme comprised only of whole numbers. Like the geometers who dreamed of “squaring the circle” and the alchemists who sought to turn lead into gold, they faced an almost impossible task, but that didn't deter them.

Most ancient calendars, including those of Greece, were based upon lunar months, but in order to keep the calendar in step with the seasons, it was necessary to insert extra months now and then, because 12 lunar months are 10.8751234326 days short of a tropical year. Each of the Greek city-states kept its own calendar, however, and the insertion of the extra, or *intercalary*, months was left to the public authorities.

In around 432 B.C., Meton of Athens noticed that 235 lunar months were almost exactly equal to 19 tropical years (the discrepancy is about 2 hours) and proposed a 19-year cycle of intercalation. Calippus, a century later, made 940 lunar months equal to 76 years each of 365.25 days. Hipparchus, the father of modern astronomy, suggested a further cycle which made 304 years equal to 3760 lunar months and 111035 days.

The Metonic cycle again became important in the early Christian church, which tied the date of Easter to the phases of the Moon, but it is significant that although the Greeks made many profound contributions to Western culture, their calendar is not one of them.

Ancient Egypt

The civilisation of ancient Egypt left to posterity some of the greatest wonders of the world. The pyramids, the Sphinx and the Valley of the Kings still haunt us, and the golden face of Tutankhamun has been seen around the world. The Pharaohs sought immortality, and after 4000 years they found it.

The ancient Egyptians also bequeathed to us the idea which is at the heart of our calendar. Unlike the Babylonians, the Greeks and early Romans, they based their calendar upon the Sun alone. As the earliest great farming civilisation, Egypt was dependent upon the annual flood of the Nile which brought water and rich silt to the river's flood plain. Life in Egypt was controlled by the seasons, and hence by the Sun. The Moon played no part in the calendar.

The Egyptian year had twelve months, each of thirty days, plus an extra five days at the end of the year. These five days were associated with the birthdays of the greatest gods of the Egyptian pantheon and were given over to celebrations.

Thus the year was 365 days long. The Egyptians made no attempt to force their calendar to keep step with the actual seasons, as we do by adding leap-days. Instead, they accepted that

the seasons would gradually become later and later with respect to the calendar, in a cycle that would take 1460 years to complete.

The Egyptians checked the relation of their calendar to the natural year not by observing the equinoxes and solstices but by the heliacal rising of Sirius, the Dog-star. This was the first sighting each year of Sirius in the morning sky just before sunrise.

Until the time of Julius Caesar, the Egyptian calendar was the only civil calendar in the ancient world in which the length of each month and year was fixed by rule instead of being determined by the discretion of priests or by the observations of astronomers. As such, it is the direct forerunner of our modern calendar.

Rome and the Julian Calendar

The calendar of ancient Rome, like that of the Greek city-states, was essentially a lunar calendar with an extra, or *intercalary*, month inserted occasionally to keep the months more or less in step with the seasons. There were twelve months, and they were named, in order: Martius, Aprilis, Maia, Junius, Quintilis, Sextilis, September, October, November, December, Januarius and Februarius. Apart from Quintilis and Sextilis, these names have come down to us almost unchanged in over 2500 years. The names of Quintilis to December are based on the Latin words for “five” to “ten”, and we can therefore deduce that the Roman year began with March.

The Romans were very superstitious. They regarded odd numbers as lucky and even numbers as unlucky, and so all of the months except February had an odd number of days: March, May, Quintilis and October had 31, February had 28 and the remainder had 29. This gave 355 days, roughly equal to 12 lunar months. The intercalary month was added, when needed, at the end of February, and on such occasions, February itself was shortened to 23 days.

Each month had three special days: the Kalends, the Nones and the Ides. The Kalends was the first day of the month, and this is the origin of the word “calendar” itself. The Nones was the 5th day of most months, but the 7th day of the long months (March, May, Quintilis, October). The Ides was the 13th, except for the long months, in which it was the 15th. Anyone who knows a little Shakespeare will remember that Julius Caesar was warned to beware the Ides of March - the 15th of March.

The Romans did not count the days of the month in the way that we do. Instead, they always counted towards the *next* of the three named days. Thus the day after the Kalends of March was not called March 2nd, but *ante diem sextum Nonas Martias* or “day six before the Nones of March”, abbreviated to *a.d. VI Non. Mar.* March thus progressed like this:

1st	Kalendis Martiis
2nd	ante diem VI Nonas Martias
3rd	ante diem V Nonas Martias
4th	ante diem IV Nonas Martias
5th	ante diem III Nonas Martias
6th	pridie Nonas Martias
7th	Nonis Martiis

The 6th, the day before the Nones, was *pridie Nonas Martias*, literally “the day before the Nones of March.” The Nones itself was included in this countdown, which is why the 5th is called the *third* day before the Nones and not the second.

After the Ides, the dates were counted down towards the Kalends of the *following* month, so that March 16th was named *ante diem XVII Kalendas Aprilis* or “the 17th day before the Kalends of April,” even though it was recognised as part of the month of March.

The Romans believed that certain days were more auspicious than others for carrying out important events such as business contracts, religious rites and even battles. Only the priests, led by the Pontifex Maximus, could tell a Roman citizen whether a given day was auspicious or not, and naturally they made a charge for each inquiry.

The priests also decided when intercalary months were needed, so they had complete control over virtually every aspect of public and private life through the calendar. However, they had no formal rules to tell them when intercalation was required, and in any case they were rather careless, so that by the time that Julius Caesar became Pontifex Maximus, the calendar had slipped by almost three months with respect to the seasons.

In order to bring the calendar back into line with the seasons, Caesar ordered that three intercalary months should be added at the end of the year which we know as 46 B.C. He also re-arranged the lengths of the months, giving each month its present duration.

But Caesar’s most significant reform was to reject the lunar month completely and to adopt a solar year whose average length was 365.25 days. He introduced the four-year cycle of leap years which we still use today. The extra day was added at the end of the Roman year, after the last day of February.

Once again, carelessness prevailed. The priests applied the intercalation every three years, not four. Perhaps it arose from the superstition: 4 is an even number, and hence unlucky. Whatever the cause, the result was that the year 8 B.C. began three days late.

Augustus Caesar corrected the error by omitting leap-years until 8 A.D., and the Julian calendar was observed without further change until the great reform of Pope Gregory XIII in 1582.

The Week

In Christendom, as in Judaism and Islam, the seven-day cycle of days of the week marks the basic period of work, rest and communal worship. In the Bible, the Creation of the world takes six days, and God rests on the seventh.

It is difficult to trace the ultimate origin of the seven-day week, but in the Babylonian calendar, the 7th, 14th, 19th, 21st and 28th days of each month were set aside for rest. After the Exile, the Jewish calendar adopted the names of the Babylonian months, and it is possible that the week was also introduced into Judaism at this time.

In early Rome, there was an eight-day cycle between market days. It was only in the second century B.C. that a seven-day cycle became predominant, and this may have owed more to

astrology than to Hebrew or Babylonian influences. Astrologers recognised seven planets (including the Sun and Moon) and assigned one planet to rule each of the 24 hours of the day, in a continuous sequence. The planet which ruled the first hour of the day was taken to rule the whole day, and this gave rise to a seven-day cycle.

The Romans began to name each day after its ruling planet: Saturn's day, the Sun's day, the Moon's day, Mars's day, Mercury's day, Jupiter's day, Venus's day. In the Romance languages, the connection is still evident. In French, for example, Monday to Friday become *lundi, mardi, mercredi, jeudi, vendredi*. In the Germanic languages, the names of the Norse gods Tiu, Woden, Thor and Freya replaced Mars, Mercury, Jupiter and Venus.

Jewish tradition originally had no names for the days of the week, giving them numbers instead. Only the Sabbath had its own name. The Roman names were adopted only slowly and reluctantly by the Jews and early Christians.

It is impossible to say whether the cycle of days of the week has continued without interruption since Roman times. The Gregorian calendar reform, though it removed ten days from the calendar at a stroke, nevertheless maintained the sequence of days of the week.

In the Year of Our Lord

A calendar is like a chain that emerges out of the waters of oblivion and holds the ship of history to its moorings. Beneath the surface of the waters, there must have been sunk some kind of an anchor. P.W. Wilson, "The Romance of the Calendar"

The calendar of Rome counted years from the legendary founding of the city by Romulus and Remus in the year we now call 753 B.C. Dates in Roman writings and inscriptions are not A.D. or B.C. They are A.U.C. - *Anno Urbis Conditae*, "in the year of the city's foundation." A Roman date would also give the names of the two men who served as consuls in that year.

British Acts of Parliament are dated by the year of the reign of the king or queen. In the United States, Presidential decrees are dated by the year since the foundation of the republic in 1776. It seems natural to measure the passage of years from some notable event.

In about the year 530 A.D., there lived a monk named Dionysius Exiguus - "Denis the Little" - from Scythia in south-west Russia. Like many scholars at the time, Dionysius was concerned with the correct calculation of the date of Easter, and he constructed a table of Easter dates for a nineteen-year period which he designated *Anni Domini Jesu Christi 532-550*.

At the time, years were measured from the beginning of the reign of the emperor Diocletian, two-and-a-half centuries earlier. Dionysius had decided, through careful calculation, that Anno Diocletiani 248 was 532 years since the birth of Jesus Christ. And since Easter commemorates the most important event in the Christian faith, Dionysius believed that it was inappropriate to date the years by the reign of one of the most notorious persecutors that the Church had ever known.

By the simple act of counting the years *Anni Domini Jesu Christi*, Dionysius gave the Western world the system for numbering the years that is still used today. It found its first

champion in the eighth-century historian, the Venerable Bede, who used it in his *Ecclesiastical History of the English People*.

Several variations upon *Anno Domini* were also used: *Anno incarnationis Dominicae*, “in the year of Our Lord’s incarnation”; *Anno a Nativitate*, “in the year after the Nativity”; *Anno a Passione*, “in the year after the Passion”; *Anno Gratiae*, “in the year of Grace”; *Anno salutae humanae*, “in the year of human salvation.”

Historians and theologians now agree that Dionysius made a mistake in calculating the year of Christ’s birth. The historical evidence makes it impossible for the Nativity to have occurred later than about 4 B.C., because that was the year in which Herod the Great is known to have died.

There is also astronomical evidence which links the Star of Bethlehem with a triple conjunction of Jupiter and Saturn in 7 B.C., an event which would have been of the greatest significance to astrologers because it meant that the two planets approached one another in the sky three times in a period of only six months.

Despite this error, the system invented by Dionysius remains the anchor which chains our calendar to its Christian origins. It is thanks to Dionysius that the year 2000 *is* the year 2000!

On the Third Day

Our calendar is a Christian calendar. Its years are counted from the birth of Christ, celebrated annually on December 25th. The other great event in the Christian faith, greater even than the Nativity, is the Crucifixion and the Resurrection of Christ. This is the event which gives hope and meaning to every Christian.

The Crucifixion and Resurrection are celebrated each year at Easter. In the early Church, these were the events which led Christianity irrevocably away from Judaism, and for almost 700 years, the date of Easter was the subject of debate, disagreement and potential schism.

In the Gospels, the events of Holy Week took place during Passover, the Jewish festival which commemorated the exodus of the Israelites from Egypt when the angel of death “passed over” the homes of the Hebrews and spared the first-born. In the Jewish calendar, Passover took place on the fourteenth day of the month of Nisan.

The Jewish calendar was a lunar calendar in which the beginning of the month was marked by the new crescent Moon, so the fourteenth day corresponded to the Full Moon. Moreover, Nisan was the first month of the Jewish year, which was arranged so that the new year began at approximately the Spring Equinox.

The early Christians, remembering their Jewish roots, continued to celebrate Easter at the time of Passover. They, like the Jewish community itself, could not say in advance when Passover would fall. This decision was the prerogative of the Sanhedrin in Jerusalem and its successors, who kept the method of determining Passover a closely-guarded secret for centuries.

By the third century A.D., the Christian churches had rejected the authority of the Jewish councils to decide the date of Passover and had begun to calculate tables of the date of Easter for themselves. This, however, led to internal disagreement. There were two diametrically opposite views. One group were still strongly influenced by the Jewish tradition that the Passover must fall on the fourteenth day of the lunar month. Their insistence on the significance of the number 14 led to them being named Quartodecimians.

The other group believed that the celebration of Easter should follow the events of Holy Week, in which the Crucifixion occurred on Friday and the Resurrection on the following Sunday. They held that Easter Day must be a Sunday, regardless of the day of the month.

The Eastern Church observed Easter on the fourteenth day of the month. The Western Church observed Easter on Sunday. This quarrel threatened to lead to schism, and it was one of the reasons which led Constantine the Great to summon the leaders of both Eastern and Western churches to the Council of Nicaea in A.D. 325. This Council is best-remembered for the Nicene Creed, the great statement of Christian belief, but it also agreed the formula for determining the date of Easter.

The Council decreed that Easter should be the first Sunday after the Full Moon following the Spring Equinox, March 21st, but if that Full Moon fell on a Sunday, then Easter should be the Sunday after.

The final phrases hint at the depth of the disagreement, for without them, it was possible that Easter might be celebrated at the time of the Full Moon, the fourteenth day of the lunar month, which was the Quartodecimian view.

Even after the Council of Nicaea, the matter was not yet settled. There remained the problem of how to predict the date of the Full Moon. The astronomers knew of at least four different cycles which linked the lunar month with the year. There was the Greek cycle which equated 8 years to 99 lunar months. There was the Metonic cycle which made 19 years equal to 235 lunar months. The Roman cycle matched 84 years to 1039 lunar months. Finally, the cycle devised by Victorius in A.D. 457 took the 19-year Metonic cycle and the 28-year cycle of days of the week within the Julian calendar and made a cycle of 532 years.

Rome used the 532-year Victorian cycle, but the church in Britain and Ireland, which had always looked first to its Celtic roots, preferred the older Roman cycle of 84 years. For two centuries, Britain and Ireland celebrated Easter on a different Sunday to Rome in certain years.

The conflict came to a head in A.D. 664 in the small fishing town of Whitby on the coast of east Yorkshire. There, at the Synod of Whitby, Wilfrid, Archbishop of York, tried to persuade Oswy, King of Mercia, to reject the 28-year cycle. In the end, Oswy announced that he would rather accept the authority of Saint Peter over that of Columba, saying: "*Then will I rather obey the porter of Heaven, lest when I reach its gates, he who has the keys in his keeping turn his back on me, and there be none to open.*" Oswy wisely did not want to jeopardise his place in Heaven. Rome had won.

Gregorian Reform

The calendar of Julius Caesar was a durable attempt to make the average length of the calendar year match the length of the tropical year. Its simplicity - add an extra day to February every four years - was its greatest virtue. By a stroke of luck, the monk Dionysius Exiguus calculated the year of the Nativity in such a way that leap-years *Anno Domini* are those which are divisible exactly by four, which is an easy rule to remember.

But this simplicity has a price. Four years in the Julian calendar are equal to 1461 days, so that the average length of the year is 365.25 days. This is 11 minutes 15 seconds longer than the true length of the tropical year. It may not seem very long - less than the time it takes to boil the kettle and make a cup of tea - but *each* year is too long by 11 minutes 15 seconds and the discrepancy builds up. After only 128 years, it becomes an entire day. Every 128 years, the seasons begin a day earlier in the calendar.

The ancient Egyptians lived quite happily with a calendar that allowed the seasons to slip by a day every four years. The Greeks and Romans were content to live with the haphazard intercalation required by a lunar calendar.

The Christian church, however, had fought bitter internal battles over the calendar, and especially over the date of Easter, which the Council of Nicaea had linked inextricably with the date of the Spring Equinox.

But the equinox was moving backward through the calendar! As early as the 8th century, the Venerable Bede had noticed that it no longer fell on March 21st, the day allotted to it by the Council of Nicaea. By the early Middle Ages, astronomers agreed that something must be done, but to change the calendar was not a step that could be taken lightly. Successive Popes studied the problem and declined to act.

It fell to Pope Gregory XIII to correct the accumulated error and to ensure that future generations would not face the same dilemma.

Pope Gregory XIII was born Ugo Buoncompagni in 1502 in Bologna. He studied law and became a lecturer and judge in his native town. In 1539 he went to Rome, and in 1549 he was sent to the Council of Trent, an ecumenical council which met fitfully over the course of some twenty years from 1545 to discuss matters of importance to the Roman Church. In 1565, Ugo was elected a cardinal and in 1572, became Pope, taking the name of Gregory XIII.

In 1577, Gregory sent a letter to all Catholic princes, describing his proposal for reforming the calendar. The letter was entitled "*Compendium novae rationis restituendi Kalendarium*", or "Compendium of a New Way of Restoring the Calendar."

By 1582, aged 80, he was ready to act. He issued the apostolic letter *Inter gravissimus* which ensured his place alongside Julius Caesar as a man who could impose his will on the very course of time itself.

The name of the apostolic letter simply means "among the most serious" and is taken from the first sentence of the letter. In full, this reads:

Among the most serious tasks, last perhaps but not least of those which in our pastoral duty we must attend to, is to complete with the help of God what the Council of Trent has reserved to the Apostolic See.

The final session of the Council of Trent, in December 1563, had left it to the Pope to complete the reform of the Mass and the breviary. The latter also incorporated a provisional calendar reform, intended to correct the calendar's predictions of the dates of New Moon, which were by now four days out of step with the real Moon. New discrepancies were to be prevented by the inclusion of an additional leap day every 300 years, from 1800 onwards. Pope Gregory called together a commission to advise him on the reform of the calendar. One of its most assiduous members was Christopher Clavius. It was the commission's recommendations that the Pope adopted in *Inter gravissimus*.

The Gregorian reform of the calendar had three parts.

First, in order to restore the Spring Equinox to March 21st, the date set by the Council of Nicaea, ten days were to be omitted from the calendar in October 1582. Thursday October 4th was followed by Friday October 15th. The cycle of days of the week was not interrupted, but October 5th to 14th did not exist in the year 1582.

Second, in order to bring the average length of the calendar year into closer agreement with the length of the tropical year, three leap years were to be omitted in every four centuries. Every centurial year which was not divisible by 400 would *not* be a leap year.

This was a clever ploy. The next centurial year was 1600, only eighteen years away at the time of *Inter Gravissimus*, and it would be leap year in the new calendar as well as the old. Nobody living through Gregory's calendar reform would ever need to worry about the revised rule for leap years.

Nonetheless, it had the effect of making 400 years equivalent to 146097 days, giving an average calendar year of 365.2425 days, just 26.8 seconds longer than the tropical year. This discrepancy would amount to one day in 3200 years. No further reform of the calendar would be needed until the 49th Century A.D.!

Third, as the new leap year rule meant that the days of the week would no longer repeat every 28 years, the 532-year cycle of Victorius could no longer be used to construct tables of the dates of Easter. A new method for computing Easter had to be devised, and it required a set of arcane corrections to allow for the fact that ratio of the length of the calendar year to that of the lunar month had also changed. The dates of Easter in the new calendar would now repeat in a cycle which was 5,700,000 years long.

Old Style, New Style

The new calendar was accepted without delay in Italy, Poland, Spain and Portugal, all of whom adopted it on the date stipulated in *Inter gravissimus*. France and Belgium moved to the new calendar in December 1582. The Catholic regions of Germany, Austria and Switzerland moved during 1583 and 1584; other regions of those countries waited in some cases until 1701.

In England, memories were still fresh in 1582 of Henry VIII's split from the Church of Rome. Elizabeth I had been excommunicated by an earlier Pope in just such an apostolic letter as *Inter gravissimus*. Nonetheless, the calendar reform met a sympathetic attitude on the part of the secular authorities. The Queen referred the matter to John Dee, a noted mathematician, who responded favourably. Dee's verdict was passed in turn to the astronomer Thomas Digges, Henry Savile, a patron of the sciences, and a Mr Chambers. All three endorsed Dee. The matter was then referred in March 1583 to the Archbishop of Canterbury, who was invited to confer with his bishops and return a reply as quickly as possible, as the Queen intended to make a proclamation in May of the following year to announce the adoption of the new calendar.

The Queen and her ministers did not receive the favourable reply that they had hoped for. The response from the English churchmen was full of invective against the Pope, who was denounced as the Antichrist. It was argued that what was done by the Council of Nicaea could only be undone by another council at which *all* the churches took part. The Council of Trent was not such a council, and since the Protestant churches regarded the Pope as Antichrist, they could never enter into dialogue with the Catholic church. There could be no second Council of Nicaea.

England would remain with the Old Calendar for another 170 years, ten days (eleven from 1700) behind of the rest of Europe and observing the New Year on March 25th. Letters to Europe carried two dates, one in the Old Style and one in the New Style.

Historians who study English events and dated documents prior to 1752 must be careful when interpreting dates. As an example, the letter from Sir Thomas Walsingham to the Archbishop of Canterbury asking, on behalf of the Queen, for his views on the calendar reform, was dated March 18th, 1582. This is an English date, in the Julian calendar. On the Continent, the year 1583 had already begun in January, and countries which had adopted the new calendar were ten days ahead. In Rome, the date was March 28th, 1583.

In the English calendar, the year changed on March 25th, a date which marked the Annunciation or Lady Day. This date, together with June 24th (Midsummer Day), September 29th (Michaelmas) and December 25th, is one of the quarter-days when rents and other quarterly charges are traditionally paid.

Thus in England, March 24th, 1582 was followed by March 25th, 1583. Historians and genealogists generally write these dates as March 24th, 1582/3 and March 25th, 1583. When writing about events in England and the Continent in the period after 1582, it is also common to indicate an English Julian date with the words "Old Style" and a Continental Gregorian date as "New Style."

Reason finally prevailed over religious antagonism. In 1751, Parliament approved the adoption of the Gregorian calendar. By this time, the Julian calendar was eleven days out of step, and so September 2nd, 1752 was followed by September 14th. The same Act of Parliament decreed that from 1752, the year should begin on January 1st.

The old calendar still lives on in the British tax year. This ends on April 5th each year, which is March 25th in the Old Style, plus eleven days.

The Age of Reason

The Gregorian calendar, aside from its rules for determining Easter, is hardly more complicated than the Julian calendar which it replaced. The regular procession of leap-years is interrupted only three times in four hundred years. Almost two centuries can elapse (from 1901 to 2099, for example) during which the Julian leap-year rule applies. And yet the Gregorian calendar will keep step with the seasons for three thousand years before a day's correction is needed again.

In the aftermath of the French Revolution, such considerations were secondary to the zeal to throw off everything which reminded the *citoyens* of the yoke of monarchy and the church. Thus the Gregorian calendar was replaced by one which paid no allegiance to religion. It was designed by astronomers and mathematicians and was held up as a product of the new Age of Reason.

It harked back to the calendar of ancient Egypt. It had twelve equal months of thirty days, plus five or six festive days at the end of the year. Each month was divided into three ten-day weeks or *decades*.

The months were given names to reflect Nature and the changing seasons. They had a certain poetry.

The winter months were *Nivose*, *Pluviose*, *Ventose* which translated to "Snow", "Rain" and "Wind". The spring brought *Germinal*, *Floreal*, *Prairial* which meant "Budding", "Flowering" and "Meadows". In summer, there were *Messidor*, *Thermidor*, *Fructidor* or "Harvest", "Heat" and "Fruitful". Autumn rounded off the year with *Vendemiaire*, *Brumaire*, *Frimaire* or "Vintage", "Foggy" and "Freezing".

The five days at the end of the year were dedicated to the *sans-culottides*, the impoverished citizens who manned the barricades despite being under-dressed. The days were named after Virtue, Genius, Labour, Opinion and Recompense. In leap-years, the sixth day celebrated the French Republic itself.

The New Year was to begin on the date of the Autumn Equinox. The new calendar began on September 22nd, 1792.

The French Republican calendar faced several difficulties. The first, and greatest, was that nobody outside France recognised it, so that the French were forced to put two dates - one Republican, one Gregorian - on any letter or document that was to be sent outside France.

The second arose when the *citoyens* realised that in place of 52 days of rest each year, the new calendar gave them only 36.

The third was the rule which governed the New Year. To conform to truly scientific principles, and to reject all historical and religious precedents, it had been decided that New Year's Day each year should be the day on which the Autumn Equinox fell, on the meridian of Paris.

The problem is that the exact instant of the Equinox varies from year to year by up to 20 minutes either side of the *mean* instant that is predicted by the length of the tropical year. The

variation arises from a combination of the *nutaton* or “nodding” of the Earth’s axis of rotation and the small deviations or *perturbations* of the position of the Earth in its orbit around the Sun due to the gravitational attraction of the other planet and the Moon.

In order to predict the amount by which the Equinox is slow or fast, astronomers can construct complicated mathematical formulae for the *perturbations* and the *nutaton* with the aid of computers. In 18th-century France, such calculations had to be done by hand, and this was very laborious and time-consuming. It was not a good way to design a calendar.

In England, the Republican calendar met with derision. There was even a parody of the names of the months:

Autumn:	<i>Wheezy, Sneezzy, Freezy</i>
Winter:	<i>Slippy, Drippy, Nippy</i>
Spring:	<i>Showery, Bowery, Flowery</i>
Summer:	<i>Hoppy, Croppy, Poppy</i>

France’s Republican Calendar, the calendar of the Age of Reason, survived almost thirteen years. In 1806, Napoleon Bonaparte ordered that France should return to the Gregorian calendar.

The Crescent Moon

There is one calendar which is central to the lives of a fifth of the world’s people and which owes nothing to Roman Emperors or Popes. It is a calendar of great simplicity, yet one whose observance has taxed the expertise of astronomers and mathematicians for over a thousand years. It is the Islamic calendar, and it is based solely upon the phases of the Moon.

The Islamic year contains twelve lunar months. It is roughly 355 days long, and moves around the seasons in a cycle of about 33 years. Each year, in the Islamic calendar, the seasons begin 10 or 11 days later than in the previous year.

The beginning of the month is marked by the sighting of the new crescent Moon by a reliable witness. It is not enough to calculate the moment of astronomical New Moon. The crescent itself must be seen in the evening sky.

Over the centuries, Muslim scholars and astronomers have attempted to establish rules to predict when the crescent Moon is likely to be visible. Such rules include criteria based upon the age of the Moon, the height of the Moon at sunset, and the length of time between Sunset and Moonset, or combinations of these.

Computers have been enlisted in the continuing search for a reliable rule, and national observatories and almanac offices are routinely asked to adjudicate in cases of disagreement. The question is especially important at the beginning and end of Ramadan, the month of fasting.

The Hebrew Calendar

In Biblical times, Jewish communities used a lunar calendar which included intercalary months at times determined by the Sanhedrin, the council of religious leaders. By the fourth century of the Christian era, this had been replaced by a calendar which followed explicit rules. It was still based upon the lunar month, but intercalary months were inserted according to the Metonic cycle which made 19 tropical years equal to 235 lunar months.

The first month of the Hebrew year is named Tishri, and it falls in the autumn. The second and third months, named Heshvan and Kislev, may have 29 or 30 days. In a leap year, the sixth month, Adar, is repeated, the first time (Adar I) with 30 days and the second (Adar II) with 29.

The length of the Hebrew year is therefore rather variable. In an ordinary year, it can be 353, 354 or 355 days long; in a leap year, it may be 383, 384 or 385 days. Years of 353 or 383 days are called “deficient” years whilst those of 355 or 385 are called “complete”.

Leap years occur in years 3, 6, 8, 11, 14, 17 and 19 of the 19-year Metonic cycle.

There are a number of rules, known as *dehiyyot*, which are used to decide whether the first day of the new year (i.e. Tishri 1) must be postponed. These rules prevent Hoshana Rabba and Yom Kippur from falling on the Sabbath, and ensure that the adjustments do not cause the length of the year to fall outside the acceptable range.

The World Calendar

The limited success of the French Republican calendar is testimony to the enduring simplicity of the calendar handed down to the Western world by Julius Caesar and Pope Gregory XIII. However, many individuals since 1582 have recognised the failings of the Gregorian calendar and suggested solutions.

The lengths of the months are a haphazard sequence. The four quarters of the year are not of equal length - in a normal year, they are 90 days, 91 days, 92 days and 92 days.

The year, whether 365 days or 366, does not contain a whole number of weeks, and so each day in the year can fall on any day of the week. The number of working days (i.e. not weekends) in a month varies from one year to the next. A phrase such as “the last Sunday in October” does not define a fixed day of the month.

Proponents of the “World Calendar” suggest a scheme which would eliminate all of these problems. They split the year into four quarters, beginning in January, April, July and October. The first month of each quarter would have 31 days, whilst the second and third months would have 30 days each, making exactly 13 weeks.

There would be an extra day at the end of the year, called Year End Day, to bring the total to 365, and in leap-years the additional day would be placed in the middle of the year, between June and July.

Each quarter would begin on a Sunday. Since each quarter contains exactly 13 weeks, the sequence of days of the week would not be broken during the year, except in leap-years. Neither Year End Day and Leap Year Day would have a day of the week, in the same way that in the French Republican calendar, the five or six year-end days had their own names.

Towards the New Millennium

The approach of the year 2000 has been keenly anticipated in the Western world. We view the end of the old year and the birth of the new as a moment for reflection on things past and hope for things to come. How much more so, at the dawn of a new century and a new millennium.

A thousand years ago, at the end of the first millennium of the Christian era, there was widespread panic that the end of the world was imminent. The Bible itself speaks of a thousand years as a special period of time, and links it with great upheaval.

Today, a thousand years later, we can take a more rational view. We no longer dread the approach of the new millennium. Indeed, the Kiribati Republic, a widely-dispersed family of islands in the Pacific Ocean, has renamed one of its islands to “Millennium Island” and declared a change to the International Date Line so that it will be the first nation on Earth to see the sun rise on the morning of January 1st, 2000!

In Britain, there was consternation in Lowestoft, the most easterly town in England, on learning that, despite its special geographical position, it would not be the *first* place in the country to see the sunrise in the new millennium. That honour goes instead to South Foreland, on the Kent coast just north of Dover.

2000? or 2001?

Does the new millennium begin on January 1st, 2000? Or must we wait another year, until New Year’s Day, 2001?

The year 2000 has such a grip on the popular imagination that it seems futile to worry about the answer, but here it is:

The third millennium of the Christian era, and the 21st century, begins on January 1st, **2001**.

Why?

Because the year 1 B.C. was followed immediately by A.D. 1. There was no “year zero,” and so A.D. 1 was the *first* year of the Christian era. The first century of that era was complete after one hundred years, at the end of A.D. 100. The second century began with the year A.D. 101 and ended with A.D. 200.

The 19th century ran from 1801 to 1900 *inclusive*, and the 20th century from 1901 to 2000. The year 2000 is the *last* year of the 20th century and of the second millennium.

Calendar pedants will celebrate the beginning of the year 2000 (with the rest of humanity!) *and* the year 2001.

Epilogue

The calendar has a powerful hold on our lives and our imaginations. It has a rich and fascinating history, interwoven with the lives of remarkable men.

It is mankind's attempt to choreograph the eternal dance of the Sun, Moon and Earth.

It has served well for two thousand years. No doubt it will serve for another two thousand!

Colophon

This document was originally written at the request of Kernow Plusfile Limited, a publisher of diaries and personal organisers, based near Cambridge, England. It appeared in their range of diaries for the year 2000.

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About the author

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His areas of astronomical expertise are celestial mechanics (calculating the orbits of planets and satellites) and positional astronomy (calculating the positions of the Sun, Moon and planets).

He currently serves on two Commissions of the International Astronomical Union (the world governing body of astronomy) devoted to these fields.

These days, David is paid to do computational biology, though he continues to enjoy astronomy in his spare time.

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