

Time, Calendar and Millenium

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The new millennium started quietly on the 1st of January 2001, unlike the wide publicity given to the Y2K problem last year. The evolution of the concepts of months and years as well as the ideas of the calendar, culminating in the present Gregorian calendar, is described. Some anomalies are also discussed, showing clearly that scientific logic must necessarily coexist with popular perceptions.

Introduction

When we say that India became independent on the 15th of August 1947, we seem to understand the timing of the event. However it causes some surprise when we hear that the so-called Russian October Revolution of 1917 overthrew the Czar, that a major underground railway station in Moscow is named Oktyabrskaya in its honor and that the event now comes in November. We feel quite puzzled. When we hear the US athletic team went to Athens in Greece for the first modern Olympic Games of 1896, keeping about a fortnight for practice, and yet found that the Games were beginning one day after their arrival in Greece, we feel that something is not right. The story behind these happenings is an old one going back to the dawn of human society.

Periodicity of the Sun, the Moon and the Seasons; Day, Month and the Year

When human beings started to notice their surroundings, the first striking observation was the rising and setting of the sun going across the sky from east to west. The day and night cycle came with unflinching regularity, as must have been noticed by all living creatures. The plants and animals depended on solar energy for their lives and the regularity of the day and night was critical. Later, perhaps, people started to notice that the other



major celestial object, the moon, behaved differently, increasing in size to become full moon and then decreasing in size to become an invisible new moon. The waxing and waning of the moon also had a regularity, which became clear when people learned to count numbers, perhaps ten thousand years ago. The cycle repeated itself once in about 30 days. Some time later, perhaps a few thousand years later because we do not have written records of these developments, people noticed that the cold season (winter) and the hot season (summer) were also regular, coming after about 13 lunar cycles. This is the beginning of the idea of a calendar; even today we have calendars based on the moon's cycles. It must be realized that the people had noticed the regularity but did not understand the reason for this regularity in those prehistoric days.

The next development, with rudimentary documentation, came from the Egyptians almost six thousand years ago. The river Nile is their life-blood, giving water and fertility to the land. They noticed that the flooding of the river, an important event for the country, also took place regularly once a year during summer time. By then the knowledge of counting numbers, whether for cattle or for slaves, had advanced. An estimate of the year, from summer to summer, was made as 360 days and the lunar month as nearly 30 days. The nations of the Mediterranean coast, the Egyptians, the Babylonians, the Sumerians, the Phoenicians, the Chaldeans and others started to use 360 days per year and 30 days for the lunar month. This had the convenience, for them, of being divisible by 6, 12, 30, 60 and other simple numbers. Indeed the division of a circle into 360° of rotation has the same link with the day being considered $1/360$ of a year and this practice of dividing the circle into 360 degrees continues even today for the same practical convenience.

The priests in the Egyptian temples made a great improvement about four thousand years ago. A priest of the temple at Thebes noticed that the bright morning star, Sirius, rose in the east in line of the temple, when the flooding of the river Nile began. They observed that the shadow of a tall pole at noon-time showed

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Table 1. Refinements of the estimates of the year.

~ 10,000 BC	1 year = summer + winter
< 2000 BC	= 360 days
~ 1000 BC	365 days
~ 100 BC	365 1/4 days
~ 100 AD	365.242... days

the same periodic changes. These were the first primitive steps towards laboratory based astronomical observations. They also realized that the motion of the star was much more precise than the flooding of the river, which could vary from year to year. Sailors, who depended on the stars for their navigation, and priests, who used the calendar for various religious purposes, realized that the observation of the stars was a more accurate method of determining the duration of the year. Thus the duration of the year was refined to be 365 days. The priests thus acquired, shall we say, magical powers in that they could predict correctly the floods and other natural phenomena. The astronomical method was a great improvement. Over the next thousand years the duration of the year was refined successively as shown in *Table 1*.

The lunar month was also refined to be 29.53 days. The astronomical linkage of the earth rotating about itself (day), the moon rotating round the earth (month) and the earth rotating round the sun (year) became the basis of all calendars. Incidentally one must not forget that the idea of the earth going round the sun was accepted only after Nicolas Copernicus advocated it clearly in the early 16th century and Galileo Galilie in the early 17th century made a small telescope to see the satellites going round Jupiter. We are using our present day knowledge to interpret the ancient observations.

While the above discussion is concerned with the total duration of the year, it was recognized that the year is too long a period for day-to-day use and one developed the ideas of months and weeks as shorter duration intervals. Further it was necessary to have some convention of when the year begins. Each country of that period had its own calendar. This did not cause any problem for

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small communities, but by the time of the Roman Empire trade was increasing and people began to move from country to country. There was an increasing need for some form of codification.

The Romans started the year in the month of March, which was the beginning of spring after the cold winter. This beginning in March is the reason that the names of the months September means 7th month, October means 8th month, November means 9th month and December means 10th month. The alert reader will note the similarity to the words 7, 8, 9 and 10 in so many Indian languages.

The Roman Calendar

The Romans started to make the months of alternately 31 days and 29 days as a result of the earlier reckoning of the year as 360 days. A little later they tried to accommodate the lunar months, since the full moon was considered particularly auspicious. 12 lunar months made only 354 days. By that time the Romans knew the year to be 365 days. So to correct for the gap, they added 22 or 23 days every 2nd or 4th year at the end of February. Thus the Roman year began in Martius (31 days), followed by Aprilus (29 days), Maius (31 days), Iunis (29 days) Quintilis (31 days), Sextilis (29 days) September (29 days), October (31 days), November (29 days), December (29 days), Ianuaris (29 days) and Februarius (28 days). The addition of 22 or 23 days would be done to Februarius once in 2 or 4 years. Such combined lunar-solar calendars are common in many countries even today. For example the practice in some regions of India to add an 'adhika masa' comes from the same reason.

In addition to starting the year in March, the Romans also started the practice of counting the years from 753 BC, the founding of the city of Rome. So the years were counted 1, 2, 3... AUC (Ab Urbe Condite) from 753 BC to start the chronology.

The addition of 22/23 days, as the correction, was to be performed by the pontiffs and the priests; in India or in the Islamic countries the date of some religious festivals is decided even now

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by the priests. While the systematic way of treating the calendar was good, the pontiffs were sometimes careless and occasionally cheated because the elections were in March. So the calendar was getting out of step with the astronomical observations. For example the winter solstice on 23rd December is the day when the apparent motion of the sun starts northwards and is the shortest day in the northern hemisphere. The spring equinox on 22nd March is the day when the apparent motion of the sun crosses the celestial equator. By the time of the great Roman Emperor Julius Caesar, the discrepancy was so big that March came when the season was still mid-winter!

Need for Common Calendar

By 50 BC, Julius Caesar was making his presence felt in Rome as the Chief Pontiff and Emperor. Around 47 BC, he was in Egypt, putting Cleopatra on the throne, and recognized the need for a better common calendar which could be used by every one. It was also essential for a good administration of the empire, like collecting taxes for administration, giving salaries to soldiers and so on. Julius Caesar took the advice of a Greek astronomer of Alexandria, by name Sosigenes, and decided to rationalize the calendar.

First he decided to use the solar based system. In the solar based calendar, the month of March always came in spring. This link with the seasons of winter, summer, rainy seasons and dry periods was obviously important for agricultural societies. Therefore over a period of time the advantage of a solar based system became overwhelming and formed the basis of modern calendars. The combined lunar-cum-solar system used earlier by the Romans had become an object of ridicule. The fact that the year was then estimated as $365\frac{1}{4}$ days and the lunar month as $29\frac{1}{2}$ days, which are not whole numbers, meant that the solution would not be simple. Sosigenes had convinced Julius Caesar that an alternate and good solution was possible.

Next, in introducing the change, he decided to invoke the



Roman god Janus, who had two faces. Julius Caesar said that it was symbolic of one face looking at the past year and one face looking at the coming year. Also 1st Ianuaris of 45 BC was a full moon day, considered auspicious. So it was decided that under the new scheme the year would begin on 1st Ianuaris 45 BC. It was necessary to invoke religious sentiments to get the acceptance of the reforms by the public. The year would be 365 days of 12 months. To correct for the fact that the actual duration of the year was 365¼ days, every fourth year would be a leap year of 366 days, adding the extra day in Februarius.

Months of the Year

The calendar introduced by Julius Caesar was a vast improvement over the earlier systems and was accepted by most of the countries of that period. It forms the basis even for the modern day systems. However Julius Caesar had many problems in introducing the system. To correct for the careless ways of handling the calendar in the earlier years, he had to make the year 46 BC as one of 445 days, i.e. adding nearly 80 days by a royal decree. However the people called it the 'year of confusion'. The new system came into force from 1st Ianuarius 45 BC. Julius Caesar himself was murdered a year later in March 44 BC and again the pontiffs and the priests made minor mistakes in adding the leap year days. Augustus Caesar, the equally illustrious nephew, became the emperor and finally corrected these slips. It was firmly installed for all legal, administrative, trade and other purposes. In gratitude, the Roman Senate renamed the old 5th month (new 7th month) as Julius after Julius Caesar. The old 6th month (new 8th month)¹ was called Augustus after Augustus Caesar and was also given 31 days, the maximum permissible. Thus we have the system of the months January (31 days), February (28/29 days), March (31 days), April (30 days), May (31 days), June (30 days), July (31 days), August (31 days), September (30 days), October (31 days), November (30 days) and December (31 days). This system of months, based on the calendar introduced by Julius Caesar, has withstood the test of time.

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¹ Once Janarius is the 1st month, Julius and Augustus will be 7th and 8th.



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Gregorian Calendar

While on the topic of calendar, it is advantageous to skip the historical events of the next few centuries and come to the 15/16 centuries, when the next major event took place. As was mentioned earlier the actual solar year is 365.2422... days. In making the year $365 \frac{1}{4}$ days, one is making a small error of 11 minutes and 15 seconds in a year or nearly 1 day in 123 years. The Julian calendar year is longer than the actual astronomical year by this small amount. The error is small, but can accumulate appreciably over 1000 years. For example the winter solstice or the spring equinox would be mistakenly celebrated 8 days earlier. Such significant accumulation of small errors over long periods of time occurs, for example, in the Indian calendars also. The festival of Sankranti is celebrated on the 14th January while it should really be the winter solstice 23rd December. The new year in some parts of India is celebrated on the 14th April, rather than on the spring equinox 22nd March as originally intended, again a slippage of nearly 22 days. By the 15/16 century, this problem with the Julius Caesar calendar began to cause some annoyance to the catholic church in that their religious festivals were getting noticeably out of step with the time of the year. Pope Sixtus IV in 1472 wanted to make a correction but died before it could be decided on and implemented. Almost a hundred years later in 1582 AD, Pope Gregory XIII took the help of the Papal astronomer, Christopher Clavius, a German mathematician and a Jesuit priest, and succeeded in issuing a Papal decree to reform the calendar.

First the new calendar made years ending in '00' leap years only if they were divisible by 400. Thus 1600 would be a leap year but 1700, 1800, 1900 would not be leap years. These changes were minimal, though the new calendar was quite accurate. Clavius had access to the accurate astronomical observations made during the earlier centuries. The new calendar year is about 26 seconds longer than the solar year, amounting to 1 day in 3323 years. Secondly the accumulated error of 'losing' nearly 10 days in the older calendar counting was corrected by making Thurs-



day the 4th October 1582 to be followed by Friday the 15th October. There were problems in the arrangement, for example in the observation of the first anniversary if a child was born or some person had died the previous year between 5th and 14th October. The authority of the church at that time ensured that the reform was accepted and the Gregorian calendar is now more or less formally followed in almost all the countries of the world.

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Calendar Riots by Workers

The Roman Catholic countries like Italy, France, Spain, etc. adopted the Gregorian calendar immediately. England, being a Protestant country, did not accept the reformed calendar till 1752; surprisingly Scotland being a Roman Catholic country adopted the reform in 1600 itself. Japan accepted the Gregorian calendar in 1877, China in 1912, USSR in 1918 and Greece in 1923. England continued with its older calendar system, which started the year on the 25th March. It was only during the reign of King George II in 1752 AD that the Gregorian system was adopted, with 2nd September followed by 14th September 1752. The introduction of the new calendar by chopping off 11 days resulted in the so-called '1752 calendar riots' among the peasants and workers in England, who felt that they were being cheated 11 days of wages by their employers.

Today these might be viewed as amusing incidents of history, like the 1917 Russian Revolution and the US team attending the 1896 Athens Olympic Games just in time, mentioned earlier. A Scottish writer would say that the execution of Charles I in England took place on the 30th January 1649, while the English writer would say that it took place on 18th January 1648, even the year being different!

7 Days of the Week

It is now important to go back to the fourth and sixth centuries AD, when a few other events of concern to us took place. The first of these events was the formal codification of the seven days per week by Emperor Constantine in 321 AD. The two very



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visible important astronomical objects, namely the sun and the moon, formed the basis for the ideas of the day and of the ‘lunar’ month. The astronomers had, by the fifth century BC, noted that five other objects (Mercury, Venus, Mars, Jupiter and Saturn) were moving relatively quickly across the sky and had called them planets. At that time they did not know about their movement around the sun, but had noticed their special orbital behavior. Thus the Babylonians, the Chaldeans and the Sumerians decided to name the days after the seven celestial objects and this practice was accepted by almost all the ancient civilizations. The Romans started the week on Sunday ‘Dies Solis’ (day of the sun) and their names for the other days are given in the first column of *Table 2*. The French names, which were also widely accepted for official purposes, are given in the second column. The Indian names given in the third column are based on the names of the same celestial bodies. The modern English names are then given. These have their immediate roots in the Teutonic and Nordic legends. Tiw is the Nordic god of war and courage, analogous to Mars. Woden or Odin is the Scandinavian god of justice who rules over the heaven. Jove or Jupiter had the Anglo-Saxon analog in Thor, the son of Woden and the god of thunder and lightning. Frig is the wife of Woden (Odin) and the mother of Thor. She is the goddess of love and affection. These names evolved from the Roman empire into German and Scandinavian usage and then into the current English language.

Table 2. Days of the week.

Roman name	French name	Indian name	English name	Meaning
DIES SOLIS	DIMANCHE	RAVIVAR	SUNDAY	SUN'S DAY
DIES LUNAE	LUNDI	SOMAVAR	MONDAY	MOON'S
DIES MARTIS	MARDI	MANGALVAR	TUESDAY	TIW'S
DIES MERCURIS	MERCREDI	BUDHAVAR	WEDNESDAY	WODEN'S
DIES JOVIS	JEUDI	GURUVAR	THURSDAY	THOR'S
DIES VENERIS	VENDREDI	SHUKRAVAR	FRIDAY	FRIGG'S
DIES SATURNI	SAMEDI	SHANIVAR	SATURDAY	SATURN'S



The Roman emperor Constantine I was converted into the Christian faith in the year 312 AD and he adopted the Roman (Julian) calendar as the official Christian calendar. He decreed the week to be of seven days and made Sunday the rest day. He then convened an important Ecumenical Council of the Christian churches in Nicaea (at that time an important city in Asia Minor and now a small village by name Nicea) in the year 325 AD and had these calendar reforms discussed and accepted. Among others the Council decreed the manner in which the Christian festival of Easter is to be celebrated, which will be discussed a little later.

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AD and BC Convention

The next major event of importance for us took place in the year 532 AD. Pope St John I felt that in the Christian calendar the chronology should start with the birth of Jesus Christ (Anno Domini or the year of the Lord). In other words the counting of the years should start from the birth of Christ rather than the earlier Roman practice of counting the years as AUC from the establishment of the city of Rome in 753 BC. Dionysius Exiguus, a monk of Scythian origin and the Papal astronomer at that time, undertook the arduous task of delineating the chronology of the Roman empire and estimated the birth of Christ in the 753rd year (753 AUC) of the Roman calendar. Thus 25th December 1 AD was taken as the date of birth of Jesus Christ. The year after it was called 2 AD and then came year 3 AD and so on. Dionysius Exiguus, sometimes called Denis the Little in English literature, called the year before the birth of Christ as 1 BC (Before Christ). This appeared logical because the notion of zero, though known to Indian scholars earlier, became known in Europe only by the 12th century through the works of the Arab scholars.

We therefore have the situation that the first century of the Christian era began on 1 AD and was completed on the 31st December 100, the second century began in 101 AD, the third century began in 201 AD and so on. Thus the 20th century



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started on 1901 AD, while the 21st century and the third millennium began on 1st January 2001 AD.

Y2K Hype

Unfortunately we have a good deal of confusion and discussions arising from a somewhat unrelated problem, namely the Y2K problems of the computers. During the 1960s, when computing systems were beginning to improve and pervade many walks of life, computer memory space was at premium. So they decided to use two digits for the years with the convention that 66 would mean 1966 AD. This was quite all right for many years, but appeared to become a problem when the year 2000 was approaching. Would 00 mean the year 1900 or the year 2000? This is the genesis of the Y2K problem. By this time, computing systems in various sizes had begun to be used in numerous daily life matters. There was worry about the possible confusion in interpreting 00 and its consequences, some of which could be serious or disastrous. The experts in computing systems however found ways of avoiding the ambiguity and there was no global crisis in going from the 31st December 1999 to 1st January 2000. However because of the wide publicity connected with the Y2K problem many are mistaken in thinking that the new century and the millennium started on the 1st January 2000. The advertisement hype to promote many events has also perpetuated this mistake.

One can now revert to the Easter festival about which an indication was given earlier. The Council of Nicaea in 325 AD felt that the linkages with the Biblical circumstances must be maintained, in particular the Hebrew festival of Passover and the Resurrection of Jesus Christ on a full moon day. Thus it decided that Easter Sunday will be the first Sunday after the full moon day which comes after the spring equinox. This combination means that Easter Sunday is not a fixed date, but can come anytime from the 22nd March till the 25th April. The complicated calculation has to be performed for every year and was a major task in the olden days. It came on the 25th April, the last possible date, in the year 1943. Such combinations of lunar



events with the solar calendar are present in other systems also. For example the Hindu festival of Diwali comes on a new moon day and so can vary by 30 days during October–November.

Enigma of the Date of Birth of Jesus Christ

Another curious twist of history is connected with the year of birth of Jesus Christ. It was mentioned earlier that Dionysius Exiguus or Denis the Little had in 525 AD worked out the chronology of the events in the Roman calendar. Jesus was born during the reign of Herod, King of Judaea, in a year which was also the census year of the Roman Empire. He fixed the date as 25 December 1 AD. This was the result of a difficult task of checking the chronicles for nearly 1200 years since the city of Rome was established. However modern careful research indicates that King Herod probably died in 4 BC and that Christ was probably born in 6 BC. A few scholars give the year as 3 BC with a slight change in the year of death of King Herod. Whatever be the result of modern scholarly research, the popular association of 25 December 1 AD with the date of birth of Jesus Christ is deeply entrenched in the minds of most people as with many other religious dogmas. The convention of BC and AD continues as a convenient one.

A further twist of history, also to be remembered in this connection, is connected with the actual date of birth. It was mentioned earlier that the Roman Emperor Constantine I got converted to the Christian faith in 312 AD. In the year 440 AD Pope Julius I introduced another link between the calendar and the Christian faith. The 25th of December is very close to the winter solstice or the reversal of the apparent movement of the Sun towards the north direction. The day was an important festival for the Romans. Pope Julius I, as a part of making a Christian calendar, decided to replace the pagan rituals with a Christian festival and associated the birth of Jesus Christ with 25th December. The Biblical references appear to indicate a different season during the birth of Jesus Christ, the beginning of the (Roman) year in spring. Nevertheless the popular association of winter snow with

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the Christmas festival of 25th December, being considered the date of birth of Jesus Christ, is now too well ingrained in the public mind to be dislodged easily whatever be the outcome of scholarly scientific researches.

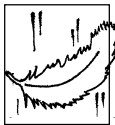
Numerous attempts to rationalize the calendar have been proposed without much of universal acceptance. The lunar month being 29.53... days, the solar year being 365.24... days and the week having seven days clearly rule out simple inter-relationships. Some element of ad-hoc arrangements is inevitable in any calendar. The lunar calendar practised by the Islamic States results in the months and the religious festivals going round the seasons of the year with a period of about 33 years. This may appear to be strange to some people. Yet they have to remember that many of the most advanced nations of the world have holidays, some of which are fixed dates of the year and some are adjusted to give long weekends, which is also a patch work. The cold logic of science has to co-exist with the popular conceptions of people.

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Suggested Reading

- [1] W M O'Neil, *Time and calendars*, Charles & Unwin, London, 1978.
- [2] F Parise, *Book of calendar*, Gauthier Villars, Paris, 1982.
- [3] A Shimony, *Tibaldo and the hole in the calendar*, Springer Verlag, Berlin, 1998.



I do not feel obliged to believe that the same god who has endowed us with sense, reason, and intellect has intended us to forgo their use.

Galileo Galilei

