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TEN DAYS LOST FOREVER

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We have finally celebrated the dawning of the new Millennium. All of us have been subjected to endless lists and retrospectives. We have had to endure the attempts of all kinds of sages to enlighten us as to their opinions of who was the greatest person, or what was the most important event of – you name it – the century, the decade, the millennium, or even of the most recent year. While to some degree, we go through this ritual every year, the whole process has been much more intense this year, because we have just entered a year that not only ends in a zero, but which, in fact, ends in three zeros! I can certainly understand our society's preoccupation with numbers that end in zero, because I recently commemorated my own 60th birthday. Nevertheless, as this paper will attempt to show, in many ways these numbers are arbitrary and really have little relevance to what they purport to represent – namely the passage of years.

We probably all believe that the year 2000 represents the 2000th anniversary of the birth of Jesus Christ. What is interesting is not only how we arrived at this reckoning, but also how we even determine the definition of a year and its length. I grew up thinking that every year is exactly 365 and ¼ days, and that this discrepancy is compensated for in our calendar by adding an extra day every four years, thus the so-called leap year. How simple it would be if that were in fact true. Certainly, Julius Caesar and his paramour Cleopatra thought so, and as we will see, although this simple and concise idea did not ultimately lead to a serviceable and workable calendar, it did give us a calendar that was used for centuries. This paper will attempt to describe mankind's long and arduous search for an accurate calendar, and the curious mix of science and religion that finally led to the adoption of the calendar which we, not only currently use, but also accept as the real representation of time.

Interestingly enough, we can directly identify the man who is responsible for our current millennial madness. His name was Dionysius Exiguus, which is literally translated as Dennis the Little. Although he may have been himself of small stature, there is nothing small about his accomplishments or ambitions. He was an abbot and mathematician who lived in Rome in the 6th century AD, a designation that owes itself to his own work. In the year 525, again a year not known in his own time, Pope John I, recognizing Dionysius's mathematical skills, asked him to calculate the dates for all future Easters. Given that the Council of Nicea had, among its other accomplishments, determined that the date of Easter should fall on the first Sunday after the first full moon after the spring equinox, such a calculation was no mean feat, particularly given the fact that the length of the year was (and is) difficult to determine.

Using the best available data of the time, Dionysius dutifully studied the positions of the sun and the moon, and he created a chart of upcoming Easters beginning in the year 532. As we have already noted, that year did not yet carry that designation. The Western world at that time numbered the years as either 1285, from the foundation of Rome, or as the year 248, based on a calendar that started with the first year of the reign of Emperor Diocletian.

Dionysius abhorred the idea of using a time line that glorified that notorious persecutor of Christians, Diocletian, and he thus came up with his great inspiration – namely, as he expressed it, "---to count and denote the years from the incarnation of our Lord, in order to make the foundation of our hope better known---". By studying scriptures and other documents, he reckoned Jesus' birth at December 25, in the year 753 from the foundation of Rome. He then restarted time just a few days later on January 1,

754 – not Christ's birthday, but the feast of the circumcision on his eighth day of life, and also, not coincidentally, New Years Day in Roman and Latin Christian calendars. This date, he designated as January 1, in the year A.D. (anno domini) 1. The preceding year, he called 1 B.C.(before Christ). As is readily apparent, there is therefore no year Zero, a fact which still bedevils us in the debates over whether the 21st Century actually began on January 1, 2000, or whether we will have to wait until January 1, 2001, for the true beginning of the new millennium. Because there was no year Zero, the 100th year of the First Century was the year 100, and the first year of the Second Century was 101. Although any accurate reckoning would therefore endorse the millennial beginning to be January 1,2001, common usage and celebrations have made January 1, 2000, the clear winner in this debate, at least in the public's mind.

We should not be too critical, however, of this crucial lapse in calculation, because in the sixth century, Western mathematicians had not yet developed the concept of zero. In fact, the first complete and usable concept of the number zero was developed by Hindu and Arabic mathematicians in the late 8th or early 9th century, and this concept was not accepted in the West until the Pope Sylvester II, who reigned from 999 to 1003, championed the concept. Obviously, all of this was way too late to help Dionysius in his calculations of the time line, and that is indeed unfortunate, because a year Zero would certainly have saved a lot of futile argument!

As if the absence of a year Zero were not problem enough, Dionysius' legacy has also provided us with another source of trouble – namely that he also got the date wrong. We know this, not because we historically know the exact date of Christ's birth, but because we do know that Herod died in the year 750 A.U.C.(from the founding of

Rome), a date which converts to 4 B.C. Therefore, because the gospels are very specific that Jesus and Herod overlapped, Jesus could have been born no later that 4 B.C. This fact leads to the paradoxical conclusion that Christ was born in the fourth year before Christ, and that we should therefore have celebrated the two thousandth anniversary of his birth/circumcision in 1996!

Dionysius and his contemporaries used what we now call the Julian calendar in their reckoning of time, a calendar which we no longer follow. However, before we delve into the reasons for our abandonment of the Julian calendar, we need to take a look at the history of the many failed attempts to come up with an accurate calendar. To us who live in an age when calendars are posted on seemingly every wall, and when every person not only wears a timepiece, but worries about its accuracy to the minute, this may seem ridiculous. Our concept of time is deeply rooted in the belief that time is immutably divided into years, months, weeks, days, hours, minutes, and seconds. But with the exception of the year and the day, which are natural phenomena that would occur without watches or computers, all these other units of time are arbitrary and made up. They are simply traditions that everyone agreed to at some point, although their origins are obscure, and nobody can at this point quite remember why they were adopted.

The day is of course defined as the length of time it takes to complete one revolution of the earth on its axis, a time which is actually subject to certain tiny variations. These variations need not concern us here, but it is of passing interest to note that the true length of the day is not exactly 24 hours, but 23 hours, 56 minutes and 4.09 seconds, or 23.934 hours. While this is not exactly an even number, it has been relatively easy and useful to round it up to 24 hours without undue calendrical mischief being done.

Defining a year, however, from the point of view, not only of devising an accurate calendar, but also in determining the passage of seasons, has proven to be a much more difficult proposition. Simply speaking, we speak of a year as the amount of time it takes for the earth to complete one revolution around the sun. However, calculating this period is a daunting task indeed, and in order to do so, it is necessary to observe the sky and keep accurate records. This is a task that is much easier in arid climates, because a succession of cloudy, rainy days obviously makes such observations difficult, if not impossible.

All of this would be much easier if the universe ran with the regularity of an ideal clock, which is an impression that has been created through the years, not only by theologians, but also by scientists. Galileo, for example, described the cosmos as "a grand book written in the language of mathematics, and its characters are triangles, circles, and other geometrical figures." The Scottish biologist D'Arcy Thompson wrote in 1917 that "the harmony of the world is made manifest in Form and Number, and the heart and soul and all the poetry of Natural Philosophy are embodied in the concept of mathematical beauty." Parenthetically, I find it interesting that, with the horror of World War I raging all across Europe, anybody could write about the "harmony of the world."

If, in fact, there were this mathematical precision to the universe and its cycles, the study of calendars would never have become an intellectual subject, and I would tonight be speaking on some other subject! But, nature's mathematical regularity has been greatly oversold, and nature is infinitely diverse and constantly surprising. In the words of the geneticist and philosopher J.B.S. Haldane, nature is "not only queerer than we suppose, but queerer than we *can* suppose."

The first human efforts to keep a record of time may have come as early as 30,000 years ago, when the Cro-Magnon men in Europe and Africa looked up at the moon and noticed that the moon's phases are steady and predictable. They then scratched what they saw onto rocks and bones and attempted to keep a record of the passage of time – i.e. the world's first calendar. In so doing, ancient astronomers came to realize that 12 lunar cycles (or "months") came very close to equaling a year of seasons. Unfortunately, it was not close enough. In fact, the lunar cycle is variable, but it averages 29.5 days. Simple mathematics shows that 12 lunar months equals only 354 days, which is at least 11 days shorter than the solar year. Although the lunar cycle was not the only natural clock used by ancient people, it was certainly the most intriguing. But, as already noted, a lunar year, because of its temporal discrepancy with the solar year, quickly became out of alignment with the seasons, flip-flopping the summer and winter solstices in just a little more than 16 years. Therefore, there developed what is called the Metonic calendar, which is named after the Greek astronomer Meton. This system, which is still used as the Jewish calendar today, allows for seven extra months every 19 years, which more or less averages 365 day years. Unfortunately, this system has not proven useful – it is too complicated, and people forget to add months or days on schedule. The extra months are called intercalated months, and they explain why the number of days in the Jewish year varies from 353 to 385. They also explain why the Jewish feast of Passover varies in its closeness to Easter. With the intercalated month, Passover is very close to Easter. However, as each lunar year progresses, Passover comes earlier and earlier, until there is another intercalated month.

The Jewish people were not the first, however, to use the so-called lunisolar calendar. The ancient Babylonians also had a lunisolar calendar of 12 lunar months of 30 days each, and they also added extra months when necessary to keep the calendar in line with the seasons of the year. The Egyptians were the first to replace the lunar calendar with a calendar based on the solar year.

Then, however, the question becomes – "How does one measure the solar year?" This is not an easy question to answer. Living in intimate contact with nature, early calendar makers noticed that when certain birds flew south, winter was approaching, and that the appearance of certain stars in the sky signaled the approach of Spring. One can also measure the length of the solar year, which is again defined as the length of time it takes for one orbit of the Earth around the Sun, in various ways. The ancient Egyptians used the appearance of the star Sirius appearing in the sky over a certain spot in the sky as the yardstick which they used to measure the solar year. Some 4000 years ago on Salisbury Plain in England, the enigmatic builders of Stonehenge made great slabs of bluestone, apparently to capture the exact moment of the summer solstice. This heroic effort made them capable of determining a year of 365 days plus several hours. An interesting modern variation of this same idea can be found in the World War I memorial in Melbourne, Australia. As we probably all remember, the Australians suffered great losses in that conflict, particularly in the Gallipoli campaign. To commemorate that effort and sacrifice, the Australians have built a memorial in Melbourne, in which the rays of the sun shine through a hole in the roof onto the remembrance stone at the 11^{th} hour of the 11^{th} day of the 11^{th} month, thus remembering the armistice of that war, which in fact occurred on November 11, 1918, at 11:00 A.M.

Thus, the Australians today count the length of the year in exactly the same way as did the ancient Egyptians and the builders of Stonehenge. But, when we talk of the solar year, we have to become very specific. What exactly do we mean by that term? As it happens, there are two different ways to define the solar year. One is the *tropical year*, which is simply defined as the length of time between two successive vernal equinoxes, which occur at the exact moment when the center of the sun appears to cross the equator, as it moves from south to north. This measurement fluctuates from year to year, and therefore the tropical year is usually calculated as a mean of several years. The tropical year differs by about four minutes from the *sidereal* year, which measures the length of time it takes for the earth to orbit the sun, returning to a starting point according to a fixed point such as a star. As it happens, the tropical year is about four minutes longer than the sidereal year, so that to measure the exact length of the year, we have to be very specific about exactly what year we mean. For the purposes of this paper, we will be talking about the tropical year.

There have probably been as many ancient calendars as there have been ancient civilizations, and this paper could become very repetitious if we were to list them all. Nevertheless, it is instructive to look at some of the old calendars, so that we can understand where we are today with respect to the calendar. The early Egyptians were some of the first people to look seriously at the annual cycle. Egyptian agriculture and life depend on the Nile and its cycles. Each year in July the river rises and floods the fields along its banks, thus irrigating the desert and depositing fertilizing silt. Although the actual date when this happens varies by several weeks from year to year, the flooding happens every year, and, as one can imagine, it became important to try to predict this

important event. Early in their history, ancient Egyptians noted that this flood was preceded by the helical rising of the star Sirius. The helical rising is defined as the first appearance of a star in the Eastern sky just before sunrise. This particular star in Egypt, rises a little earlier before dawn than on the night before as the days progress. Finally, after several months, the star sets at dawn, following which it remains invisible for 70 days before it reappears, thus signaling the beginning of the flooding season. This interval between successive helical risings is determined by the sidereal year and the times of sunset. At the latitude of Thebes, this interval was about 365.2507 days – about 12 minutes longer than the tropical year which governed the flooding of the Nile, but for the ancient Egyptians, this was accurate enough.

However, as time progressed, the Egyptians became dissatisfied with this reckoning of time, and they ultimately developed their own civil calendar. The Egyptians, after all, are renowned for their civil engineering. It required considerable logistic skill to organize, house, and feed the thousands of workers who built the pyramids and their other great monuments. This organization, in turn, required an army of bureaucrats and a system of taxation (to pay for it all), which in turn necessitated the keeping of accurate records. This need, in turn, led to the development of their civil calendar. Basically, they observed that the period between the helical risings of Sirius was usually 365 days. They thus divided the year into 12 months of 30 days each, and they attached the extra five days at the end of the year. These days were usually, but not always, holidays. This year was convenient and easy to use, but since the civil year of 365 days was about a quarter of a day shorter than the mean tropical year, it started about one day earlier with respect to the seasons every four years, and in about 1500 years, it

would have fallen behind by a whole year. This ultimately became unacceptable to the Egyptians, and they altered their calendar in a complex way, using both the lunar and solar years, to arrive at a calendar cycle which basically arrived at the use of a year of 365 ¼ days, with the addition of an extra day in the year every four years. This calendar was officially adopted in 238 B.C. , when the emperor Ptolemy III ordered the adoption of the leap year system.

Meanwhile, the Romans, who came to be the conquerors and rulers of the known Western world had developed their own calendric system, which was based on a 12 month lunar year. This calendar had occasional months and days intercalated by priests to keep the calendar year more or less in line with the seasons. Unfortunately, over the centuries, their calendar had drifted back and forth because the priests had either neglected to insert extra months or because they intentionally manipulated the calendar for political reasons, for example to increase the length of the year to keep consuls and senators they favored in office longer, or conversely to shorten the year to decrease political rivals' terms. They also frequently misused the calendar to increase or decrease taxes and rents, frequently for their own personal financial advantage.

By legend, the Roman calendar was created by the mythic first king of Rome, Romulus, when he founded the city in what is now known as 735 B.C., but which was the year 1 in the Roman calendar, known as *ab urbe condita*, which in Latin means "from the founding of the city". This calendar was based, like many others, on the lunar cycle, but for unknown reasons, this year was composed of only 10 lunar months, for a year that totaled only 304 days. This infatuation with the number 10, which the Roman poet Ovid speculated may have been "because that is the number of the fingers by which we are

wont to count," led to the naming of the months which we still use today. Apparently, Romulus ran out of imagination, and after naming the first four months after various gods – Martis, Aprilis, Maius, and Junius, he simply fell into counting the months, thus naming them 5, 6, 7, 8, 9, and 10 (Quintilis, Sextilis, September, October, November, and December). This explains why the ninth, tenth, eleventh, and twelfth months of our calendar still bear the Latin symbols for 7,8, 9, and 10.

Well, Romulus' 304 day calendar did not last long, because it was entirely unworkable for an agricultural society that needed a reasonably accurate calendar to guide it through the seasons. Romulus' successor, King Numa, added two months to the calendar year in about 700 B.C., which would have been around 35 A.U.C. These two months, Januarius and Februarius, brought the year to the standard lunar year of 354 days. Numa added another day to this year, because of a Roman superstition against even numbers.

Although the 355 day year was a considerable improvement over Romulus's 304 day calendar, it didn't take long for Roman farmers to figure out that it too was flawed and could not keep in line with the seasons without days and months intercolated at various times. The Romans tried several schemes to try to keep the calendar in sync with the year, but none of them worked very well. They adopted a year based on a version of the Greek calendar that inserted intercalary months every eight years. Although this system brought their calendar roughly in line with a 365 day year, the system was very confusing, and as I have mentioned earlier, for a variety of reasons, the priests frequently forgot to slip in the extra months at the proper interval, so that the calendar often slipped back and forth against the solar year. Indeed, by the time that Julius Caesar returned

home from Egypt and his other wars in 46 B.C., the calendar was in a shambles and the Roman year had veered off the solar year by almost two full months. This situation was clearly unacceptable, not only with farmers and sailors, but also with a population that was becoming more dependant than ever on trade, commerce, law, and civil administration in a rapidly growing empire that desperately needed a standard system for measuring time.

On a balmy October evening in Alexandria, Egypt, in 48 B.C., as the Roman general and dictator Julius Caesar languished in his apartment, a small ship slipped through the defenses of Alexandria's harbor and landed on a stone wharf, carrying an unlikely cargo that would not only profoundly affect the politics of the day, but which would lead to a revolution in measuring time that is directly responsible for the calendar which is virtually in universal use today throughout the world.

After the boat landed, a Sicilian named Apollodorus jumped ashore and carefully lifted onto his back a rolled up rug, which he carried by the guards, explaining that he bore a gift for the Roman dictator. After he was led to Caesar's apartment, Apollodorus greeted the general by unfurling the rug, which concealed, not just a woman, but the magnificent woman, Cleopatra. Although she had just emerged from a bedroll and could not have looked her best, she obviously profoundly impressed Caesar with her beauty and sexual allure. Although Caesar and Cleopatra could hardly have had the calendar on their minds on this particular night, ultimately their liaison did lead to significant calendar reform. Indeed, after Caesar had satisfied his earthly desires, he began discoursing with a scholar attached to Cleopatra's royal court, an elderly wise man named Acoreus. During this conversation, Caesar asked questions about the source of the Nile, the history of

Egypt, and about the country's calendar. It was then that Caesar heard about Egypt's reliance on the sun for its year – measured by the annual rise of the star Sirius in the eastern sky and by the flooding of the Nile, which the Alexandrian sage said, "does not arouse its water before the shining of the Dog-star".

Caesar was infatuated not only with the beautiful and seductive Cleopatra, but he was also infatuated with Egypt itself, which , even in Caesar's day was an ancient and mysterious land. The city of Alexandria, where Caesar had his first meeting with Cleopatra, was also a feast for the mind, and it was here that Egypt's great astronomers wrestled with the question of the year and its length. Although the Alexandrians probably knew that the year was not exactly 365 ¼ days, Caesar himself left Egypt in June of 47 B.C. with, not only a pregnant Cleopatra left behind, but a new concept of the year and the calendar. When he returned to Rome, the Senate named him dictator for ten more years, commissioned a bronze statue of him to be erected in the Forum, and ordered a celebration of forty days for his victories in Gaul, Egypt, Syria, and Africa.

The subsequent celebration became notorious in Rome for its excess and debauchery, and already Caesar's enemies began talking darkly of a man whose success and virtually limitless power were turning him into a monster. These sentiments ultimately led to his assassination, but in the meantime he governed mostly with energy and resolve, and accomplished a great many deeds which are not of importance to this paper. However, his greatest and most dramatic measure was the reordering of the Roman calendar, which was done sometime in the first half of 46 B.C. Although this reform was a potent symbol not only of Julius Caesar's authority as the dictator of Rome, but also of an empire that believed it had the power to reorder time, Caesar, who was,

among other things, a veteran general and statesman, based his new calendar on the science he had learned in Alexandria, and not on vanity or religious dogma. In any event, Rome's old lunar calendar was in desperate need of reform, because it ran, at that time, several months fast against the solar year.

To fix the calendar, Caesar called in the best philosophical and mathematical minds of his time. The core of the reform was to institute a year of 365 ¼ days, which was identical to the system ordered in Egypt by Ptolemy III in 238 B.C. The fraction was corrected by adding an extra day to every fourth year, thus adding the leap year of 366 days. As if that were not change enough, Caesar determined that the calendar should be immediately brought back into alignment with the vernal equinox, which was supposed to occur on March 25. In order to accomplish this feat, Caesar, in an extraordinary feat of leadership, ordered two extra months added to the year 46.B.C., which were inserted between November and December. Combined with an intercalary month which had already been installed in February, the entire year of 46 B.C. lasted an incredible 445 days. Although Caesar called this year the "ultimus annus confusionis," "the last year of confusion", everyone else simply called it "the Year of Confusion." And no wonder – this year was confusing not only because of its extraordinary length, but also because of the dizzying pace of Caesar's changes.

The extra days in 46 B.C. caused disruptions throughout the Roman world in everything from contracts to shipping schedules. Cicero complained that his old adversary, Julius, was not just content with ruling the world, but also strove to rule the stars. Nevertheless, most Romans were relieved to at last have a stable and objective calendar that was not based on the whims of priests and kings, but on science.

Caesar rounded out his calendar reforms by moving the first of the year from March to January. He then reorganized the lengths of the months to add the required extra 10 days to bring the year from the previous 355 days to 365 days. All months alternated between 30 and 31 days, except for February, which had 29 days in a normal year and 30 days in a leap year. Finally, the Senate took one of February's days and added it to the month Quintilius, which then became July, in honor of the instigator of this calendar.

So, when the new day dawned on January 1, 45 B.C, - or 709 A.U.C.- Romans, and therefore most of the Western world awoke with a new calendar, which was then one of the most accurate in the world. Even so, it remained subject to errors and tinkering by priests and politicians, the earliest of which occurred soon after Julius' death when the priests began counting leap years every three years instead of every four. Although the calendar was quickly thrown off, this error was easily fixed later by Augustus Caesar, Julius Caesar's nephew, who ordered the next three leap years skipped, thus restoring the calendar to its proper time by the year 8 A.D. Thus was finally instituted the Julian calendar, which was to remain the official calendar for the next 16 centuries. The only other matter which we need to address in this context is that Augustus was not content until the Senate finally renamed the month Sextilis in his honor and added another day to bring it to a 31 day month, thus giving us the month of August. Because of this switch, Augustus switched the lengths of September, October, November, and December, and this left us with that annoying old English ditty, which, incidentally, I have never been able to remember:

Thirty days hath September

April, June and November,

February has twenty-eight alone

All the rest have thirty-one.

Excepting leap year – that's the time

When February's days are twenty-nine.

So, we finally had a calendar which was based on the true solar year. The only problem was that the year is not exactly 365.25 days long. In fact, the true length of the year is a mind-numbing and inconvenient 365.242199 days, a difference which is about 12 minutes. While one could reasonably ask what possible difference 12 minutes in a year could make, the fact is that over long periods of time, it *does* make a difference. In fact, using the Julian calendar leads to a difference of one day every 128 years from the true year, so that the calendar gradually drifts ahead of the true solar year at a rate of one day every 128 years. Again, this doesn't seem like such a big deal to those of us who have a lifetime of 80 or so years, but as the centuries progress, the difference does finally become significant. It is worthwhile to note that if we were still using the Julian calendar, there would today be a 16 day difference between the calendar year and the solar year.

Nevertheless, the use of the Julian calendar led to a useful way to count the passage of time, and most, if not all, people would never have noticed, if it hadn't been for the feast of Easter, which, as we all know is the time when Christians celebrate their central mystery of the Crucifxion and Resurrection of Jesus Christ. Christianity is a

historical religion – that is to say that it is based upon real historical events. Ultimately, therefore, dates were, and are, important to it. Consequently, by the middle of the second century, the problem of exactly when Easter should be celebrated had arisen. The bible clearly puts the crucifixion and resurrection around the time of the Jewish feast of the Passover, but many early Christians were reluctant to tie their central ritual to the feast of another religion. Thus, the dating of Easter became very important early in the history of Christianity.

This issue was directly addressed in 325 A.D. by the Council of Nicea, which, as we all know, gave us the Nicene Creed, which is still the core of the doctrine of Christianity. However, the bishops at Nicea also confronted the problem of Easter and exactly when it should be celebrated. While we have no records of the debates of the bishops concerning the date of Easter, we do know that they decreed that Easter Sunday, the anniversary of the Resurrection, was to be celebrated on the first Sunday which came after the 14^{th} day of the paschal moon, which basically became the first Sunday after the first full moon after the Spring equinox. But, the bishops didn't want to use true solar calculations, because they did not want the calculation to be based on the calculation of Passover. Therefore, they designed their rule to ensure that, among other things, Easter Day was never on or before the Jewish Passover. As a result, they decreed that the Spring equinox would always occur on March 21, and that Easter would always occur on the Sunday after the first full moon after March 21. Incidentally this rule is interesting, because it directly combines facets of both the lunar and solar years. Unfortunately, the length of the Julian year did not properly match that of the true tropical year, and the average length of a notional lunation did not match the mean synodic period of the moon.

As the centuries passed, the date of the actual vernal equinox fell earlier and earlier before the assumed calendar date of March 21. To those who noticed such things, it began to be obvious that the intentions of the Council of Nicea were being thwarted

Thus it was that some seven centuries ago, in the 13th century, a sickly English friar named Roger Bacon dispatched an urgent message to the Pope Clement IV in Rome. Bacon, who was no relation to the much more famous Sir Francis Bacon, who lived three centuries later, was one of medieval Europe's most original and curmudgeonly thinkers. Insatiably curious and always willing to challenge orthodoxy, Bacon spent his life pondering the scientific mysteries of the world, most especially including those of the calendar. Bacon's message to the Pope, who had known and been interested in Bacon and his ideas before he became Pope, was nothing less than an urgent appeal to set right time itself. Bacon calculated that the calendar year was some 11 minutes longer than the actual solar year. Although we now know that the number is closer to 12 minutes, Bacon had the basic idea right, and he informed the supreme pontiff that this error amounted to an error of an entire day every 125 years, a surplus of time that had accumulated from Caesar's day to Bacon's day to nine days. Left unchecked, this drift would ultimately shift March to the dead of winter and August to the spring. But even worse than that was Bacon's pious insistence that Christians were celebrating Easter and every other holy day on the wrong dates. Bacon wrote in 1267, "The calendar is intolerable to all wisdom, the horror of all astronomy, and a laughing-stock from the computors (by which he meant mathematicians) point of view." Bacon got the attention of the Pope, who invited Bacon to write down and present his thoughts to him. Bacon prepared a series of treatises that not only presented his ideas about time and the calendar, but which were also highly

but which were also highly critical of the Church, but, unfortunately both for him and the cause of calendar reform, Clement died soon after Bacon finished them. Clement's successor, Gregory X, did not share his interest in Bacon's ideas, and the unfortunate excentric did not live to see his thoughts vindicated. In fact, he was ultimately imprisoned by the church for his heresies, and he died a beaten, broken man whose ideas were either ignored or repudiated. Nevertheless, his passion for truth endured, and centuries later, Roger Bacon became a posthumous hero of late Renaissance and Enlightenment thinkers.

With the death of Clement, died the hopes of Roger Bacon for the reform of the calendar, at least for the time being. However, in 1345, the newly installed pope at Avignon, Clement VI, abruptly decided that the calendar needed to be reformed. This pope, who was known for his pomp, extravagant living, and his patronage of the arts, dispatched letters to calendar experts in 1344, asking them to come to Avignon to consider and advise on the correction of the calendar. Although much work and research was done on the problem, the whole process was ended by the death of the pope, who probably agreed with the reforms, from the Plague, which not only killed him, but also about 1/3 of the population of Europe.

There developed subsequently several attempts by various popes to fix the calendar, but for various reasons, they never succeeded. The Avignon antipope, John XXIII, not to be confused with the modern pontiff of the same name, in response to the Council of Constance, issued an edict in 1412 to correct the drift in the calendar by removing four days. However, amidst the turmoil of dueling popes, John's decree was ignored, and thus was lost yet another effort to correct the calendar. By 1500, the

calendar had drifted away from the true seasons of the earth by over twelve days since Caesar, and over nine days since the Council of Nicea. No one could measure this error exactly, but every intellectual acquainted with mathematics, astronomy, or theology knew that it existed. The problem was twofold: how to fix it, and who made the decision.

As far as the latter question was concerned, there was no doubt in the Church's mind that the Church was the proper institution to fix the problem. How to do it was a much more vexing question. The great Polish-German astronomer, Copernicus, worked on the problem for more than 30 years, during which he wrote his great work, *De revolutionibus*, in which he expounded on the Earth's revolution around the Sun. He also, incidentally, talked about the length of the year, and how it differed from the length of the calendar year. But, finally, great as it was, the work of Copernicus, only set the stage for three men – a mathematician from Bavaria, a physician from southern Italy, and an elderly pope named Gregory, who finally came up with a most elegant solution to fix the calendar, but, even more importantly, to enact that solution.

Of the three great calendar reformers, the pope, Gregory XIII, is the most unlikely hero in this scenario, but in fact, in my opinion,, he is the greatest of them all. He was an old man when he became pope, and he definitely had a hard side to him. Thus, when the news of the St. Bartholomew's Day massacre of the Huguenots in France reached Rome in August, 1572, he celebrated the event with a *Te Deum*, which was a hymn of praise sung on special occasions. He also actively supported attempts to assassinate the Queen of England, Elizabeth, I. Nevertheless, as we shall see, when he was confronted with the problem of the calendar, and the opportunity to correct that problem, he not only recognized the problem, but he also seized the opportunity to solve the riddle of time.

In this day and age when we are all used to the appointment of a committee to solve a problem, with the subsequent presentation of a report, which is usually either ignored or changed beyond recognition, it is interesting to note that Gregory, when confronted with the problem of the calendar, appointed a calendar commission which not only directly addressed the issue, but actually came up with a solution which was not only workable, but also accepted .

Just exactly who was this man who became the pope who gave us our current reckoning of time? Born in 1502, Ugo Buoncompagni, who was to become Pope Gregory XIII, was the son of a noble Roman family. He became a prominent ecclesiastic lawyer and senior papal official before he was elected pope at the age of 70 in 1572. Although he worked hard to rebuild the authority of the Church and to reform its worst excesses, he was also zealous in trying to stamp out Protestantism. He also suppressed knowledge that failed to agree with Church dogma and established an infamous index of banned books that later listed Copernicus's *De revolutionibus*.

Furthermore, he was a man who enjoyed pomp and celebration, and he supported grandiose building projects in Rome which nearly bankrupted the Vatican treasury. So, with all of these negatives, Gregory is remembered as the pope who finally corrected time. The question remains: Why was it *this* pope who finally corrected the calendar? Part of the answer lies in the fact that he was pope at the right time for calendar reform – a reform whose time had come. He had served on the staff of Pope Pius IV at the Council of Trent, when the issue of calendar reform had once again been brought to the attention of a pope. Pius IV died before he could solve the problem, and his successor, Pius V, did not directly address the problem. When Pius V died, Gregory ascended to the

pontificate, and he believed that the work of the Council of Trent had not yet been fulfilled. He therefore undertook to reform the calendar, and he appointed his commission, which worked through the 1570s and early 1580s.

Except for the nine members who signed the final report to the Pope in 1581, the members of this commission are unknown. Most of the remaining nine are not important, but there are two whose work was critical – the physician Antonio Lilius and the Jesuit astronomer, Christopher Clavius. Clavius's main role was as the man behind the scenes who championed the reform and shepherded it through the minefields of scientific and ecclesiastic controversy before and after it was adopted in 1582.

Soon after he had become Pope, Gregory had been presented with a proposal which had originally been written by a physician, Aloysius Lilius. Aloysius had met an untimely death, so his proposal had been presented by his brother, Antonio Lilius, who was also a physician. Antonio presented his brother's ideas to the commission in 1576, an event which Gregory mentions in his 1582 bull by recalling that "a book was brought to us by our beloved son Antonio Lilio, doctor of arts and medicine, which his brother Aloysius had formerly written."

This "book", which no longer exists in its original form, was easily the most important document in the entire reform process, because it led to the determination of the length of the year, upon which the calendar reform was based. Without getting bogged down in the details, it should be mentioned that at that time, no one had yet come up with a method for determining the true length of a year beyond a doubt. Given the variability of the earth's movements, this issue has not yet been entirely resolved today. But, even in the 16th century, advanced astronomers such as Clavius and Lilius

recognized that the length of the year is variable, and that in order to have meaningful calendar reform, this fact would have to be recognized. The calendar commission wrestled with this problem for years, before they finally came up with the mean value for the year which they used in the reform itself, which is 365 days, 5 hours, 49 minutes, and 12 seconds – a year which runs only 26 seconds slower than the true year

Once Lilius and the commission had decided on the mean year, he pondered the next crucial problem of reform, i.e. how to close the gap between Caesar's year and the "true" year. This meant comparing the Lilian year of 365 days, 5 hours, 49 minutes and 16 seconds to the Julian year of 365 days, 6 hours. The Lilian year runs short of the Julian year by 10 minutes, 44 seconds – equal to a day lost every 134 years. As Lilius tinkered with various solutions to this gap, he realized that it amounted to three days gained against the true year every 402 years (134X3). He rounded this off to three days every 400 years, a more accessible number that became the basis for the so-called leap-century rule, by which our calendar still lives today. This rule states that we will have a leap year every fourth year, except in those years that end in two zeros, except that in those years that are divisible by 400, there will be a leap year. Thus, there was no leap year in 1700, 1800, and 1900, but this year of 2000, is, in fact, a leap year. Considering that we now know that the true year runs about 12 minutes short of the Julian year, the gap between the Lilian year and the Julian year being a day lost every 128 years, this calendar reform becomes even more workable. In fact, the formula ends up being remarkably accurate, running ahead of the seasons by only one day every 3,300 years! This is in fact the formula adopted by Gregory's calendar commission.

Well, like most committees, Gregory's calendar commission had to distribute its report and get a public response before it would issue its final report. Predictably, there was considerable criticism, but finally, a decision had to be made. Would the report be issued, or wouldn't it? Here is where the 79 year old pope exerted great leadership. He enthusiastically supported the plan, which was set for implementation in October, 1581. He chose October, because it is a month with few holy days. This was delayed for a year while the commission waited for a report from a Flemish scholar, Adriaan van Zeelst, which, as it turned out, did little except delay the report for a year.

Finally on February 24, 1582, the 80 year old Pope Gregory XIII sat down and signed the bull that would make 1582 the last year of Julius Caesar's calendar. The text of the papal bull was posted on the doors of St. Peter's and the basics of the new system were dispatched to every Catholic country. Although, he had had a lot of help, Gregory deserves the honor of having this calendar named after him, simply for the sheer bureaucratic feat of pushing through the reform when so many others had failed. A great deal of controversy would have been avoided, if the pope had decided, as he had been advised, to make the change gradually – one day a year for 10 years. But, Gregory chose to make the change dramatically and all at once. Thus, when bells chimed across Europe in the waning moments of October 4, 1582, the calendar did something it had not done since Julius Caesar's time: it jumped 10 days. Therefore, those Europeans who were paying attention, went to bed on the night of October 4, and they awoke on the morning of October 15. Thus, anyone who was alive on what would have been October 5, instantly lost 10 days of his or her life, according to Rome's new calendar, and they lost 10 days forever. This change genuinely upset people, who felt that the days had

somehow been stolen from them. There were riots in Frankfurt, while elsewhere, while there was not violence, people openly expressed their fear and unease at upsetting the saints to whom they prayed for everything from good crops to the afterlife.

Equally serious, although more mundane, were the sailor, weavers, swordsmiths, and kings who worried about taxes not collected, wages not earned, and deadlines coming due 10 days early. Even the birthday of the pope had changed: from January 1, 1502, to January 11, 1502.

Even worse than these convulsions, however, was the fact that very few countries actually enacted these hard fought changes. In fact, most people who went to sleep on October 4, 1582, awoke, at least in their minds, on October 5, 1582. As bad as that was from the point of view of calendar reform, even more confusing was the fact that only a scattering of countries actually enacted this reform. Unfortunately, Gregory had announced his calendar reform in the context of a papal bull, and while that vehicle, had it been issued even a century earlier, would have been almost universally acknowledged, in 1582, the continent of Europe was torn apart by religious strife between Protestants and Catholics.

Set against this backdrop, Gregory's bull was a regrettably political document, and it was viewed as a strident command from the pope. Although Clavius and others insisted that the bull was never intended to be provocative against rival churches, in fact, because the pope took as his authority the Council of Trent, which was primarily a tool to stop the Protestant Reformation, it was virtually guaranteed that non-Catholics would resist the reform as an illegal and immoral edict from a papacy which they did not recognize.

Although the staunchly Catholic countries immediately complied with the papal bull, those countries less secure in the fold, or, for whatever reason less in a hurry, did not immediately comply with the pope's directive. France waited until December to comply, while Belgium, the Netherlands, and Flanders made the jump on December 21, which was followed by January 1, which meant missing Christmas of that year. By 1587, virtually all of Catholic Europe had adopted the Gregorian calendar.

Naturally, the Eastern Orthodox Church rejected the reform, because of the centuries old enmity between the two churches, even though the Roman Church made a determined effort to include them in the calendar reform. This effort included the sending of a calendar emissary from the pope to the patriarch of Constantinople. Although the patriarch himself was sympathetic to the cause of calendar reform, the whole reform effort was sabotaged by the news that Gregory had unilaterally issued his reform in the context of a papal bull. A synod held in Constantinople in November, 1582, harshly condemned the reform as being against tradition, the Scriptures, the councils, and the wishes of the founders of the Church. The Orthodox Christians have been the longest holdouts against the Gregorian calendar reforms, and even today, because of the different calendars, they celebrate Easter on a different day than do Western Christians. We probably noticed that difference during the recent Kosovo bombings, when we were asked to suspend the bombings for the Serbian Easter, which was different from ours.

But, nowhere was the turmoil over the calendar more evident than in England, which was in the early 1580's virulently anti-Catholic. At that time, England was a small, weak , and isolated island kingdom, which was ruled by Queen Elizabeth, a

Protestant queen who had spent her entire reign trying to protect herself and her realm against the great Catholic powers of the day, particularly Spain. Surprisingly, the Queen was herself favorably disposed to the Pope's calendar reforms, but her advisers, led by John Dee, who studied the issue in great detail, advised her not to go along with the reform. As a result, England, and therefore her colonies, which included America, failed to acknowledge the Gregorian calendar reform.

It would be another 170 years before Britain finally adopted the Gregorian calendar, it being one of the last major European countries to do so. As Britain became a major international military and economic power, the inconvenience of using a calendar which nobody else used became increasingly a nuisance for businessmen and an embarrassment for anyone with connections on the continent. Still, as the years passed, most people in England and its colonies seemed to take the inconvenience in stride, even to the point where they often dated their correspondence with two dates – o.s.(old style), and n.s(new style), where o.s referred to the Julian calendar in use in Great Britain, and n.s. referred to the Gregorian calendar in use everywhere else in the Western world.

There the matter stood until May,1750, when a stodgy earl named George Parker addressed the issue of the calendar before the Royal Society. His speech inspired the recently retired secretary of state, Philip Dormer Stanhope. Stanhope then took the cause to his friend, the future prime minister Thomas Pelham. Although he initially met resistance, Stanhope finally won Pelham's approval to introduce a bill in Parliament to reform the calendar, and this bill sailed through parliament on May 17, 1750. This act ordered 11 days expunged from the calendar, there having been lost already another day from Gregory's time.

Stanhope and Parliament took pains to legislate details of the changeover to minimize problems with banking, contracts, holidays, and other matters, both public and private. There was also a broad public relations effort, which included not only the government, but also the Church of England, which tried to make the public not only aware of the change, but also accepting of it. The act of parliament ordered 11 days expunged from the calendar in Great Britain and its colonies, with Wednesday, September 2, 1752, followed by Thursday, September 14. Furthermore, the act ordered that the new year would begin on January 1, rather than on March 25, as had been in the old calendar. March 25 had been recognized as the first day of the year because it was Lady Day, the day, nine months before Christmas Day, when the Angel Gabriel is said to have appeared to the Virgin Mary to announce to her her pregnancy with Jesus. These were significant changes, as is illustrated by George Washington, whose birthday not only changed from February 11 to February 22, but also from 1733 back to 1732.

In spite of all the efforts of the English government to prepare and educate the public, many people in Britain reacted with dismay when the September dates actually rolled around. In London and elsewhere mobs collected in the streets and shouted, "Give us back our 11 days!" In the City of London, bankers protested the reform and the confusion it caused for their industry by refusing to pay taxes on the usual date of May 25, 1753. Instead, they paid up 11 days later, on April 5, which remains tax day in Britain even now.

Late as it was, Britain was not the last country in Europe to change to the new calendar. Sweden changed the next year, in 1753. There was then a long gap, before the Greek Orthodox countries finally made the switch – but then only for civil purposes, but

not for religious ones. Russia did not make the change until 1918, after the Bolshevik Revolution, by which time they had to drop 13 days (February 1-13) to catch up with the Gregorian calendar. Incidentally, this explains the curious fact of why the Soviet Union always celebrated the anniversary of the October Revolution on November 7.

In Asia, Japan adopted the Gregorian calendar in 1873, and China did not completely adopt the new calendar until the Communists took over in 1949. On October 1 of that year, a triumphant Mao Zedong stood atop the Gate of Heavenly Peace in Beijing, where he then made three decrees – Beijing would henceforth be the capital of China, the red flag with a large gold star and four small stars would be the official flag of China, and finally that the Gregorian calendar would be the official calendar of China.

Thus this calendar, launched 2000 years earlier by Julius Caesar and modified 1600 years later by an otherwise lackluster pope, has become the world's calendar: a code for measuring time that is used today by virtually all of the world's people as the global standard for measuring time. It is used today, in spite of its odd quirks and the history of religious and political differences which made it controversial, because it has one cardinal virtue – it works! Although the Gregorian calendar runs fast against the true year by about 25.96 seconds a year, this difference, which has accumulated to about 2 hours, 59 minutes and 12 seconds since Gregory's time, will not accumulate to an entire day until the year 4909. There have been efforts at calendar reform since Gregory's time, most notably by the French after their 1789 revolution, but none have been successful, and I suspect that we will continue to use the Gregorian calendar for a long time because we are used to it, and because it functions effectively.

So, what really is this year 2000? Well, by our common reckoning, it is the 2000th year of the Christian era and therefore the last year of the second millennium. But, it is also the following years:

The 2004th anniversary of Christ's birth

The year 2753 according to the old Roman calendar

The year 2749 according to the ancient Babylonian calendar

The year 6236 according to the first Egyptian calendar

The year 5760 according to the Jewish calendar

The year 1420 according to the Moslem calendar

The year 2544 according to the Buddhist calendar

The year 1378 according to the Persian calendar

The year 1716 according to the Coptic calendar

The year 208 according to the calendar of the French Revolution

The year 5119 in the current Maya Great Circle

The year of the dragon according to the Chinese calendar

So, Happy New Year, and enjoy the new millennium!