The Gregorian Calendar

Pope Gregory XIII began the modern calendar 400 years ago in order to correct the accumulating drift in the Julian calendar and keep Easter in the spring

by Gordon Moyer

In 1582 Pope Gregory XIII introduced the calendar named in his honor; it is the system of reckoning days currently in civil use throughout the world. Before the inception of the Gregorian calendar Western civilization depended on a system instituted by Julius Caesar, called the Julian calendar. For more than 16 centuries this system remained in service in spite of an accumulating discrepancy between the mean length of its year, 365.25 days, and the tropical year, the average interval between successive transits of the apparent sun through the vernal equinox. By 1582 the error in the Julian system had grown to approximately 11 days. This defect was of principal concern to the pope; if the Julian calendar had continued in service, Easter would eventually have been celebrated in the summer.

Pope Gregory assembled an eminent body of astronomers, mathematicians and clergymen for the reform of the Julian calendar. The commission faced a fundamental problem inherent in all civil calendars: for obvious reasons a calendar designed for ordinary service must have a whole number of days; it cannot simply leave a fraction of a day dangling at the end of the year. One of the leading members of the commission, the Jesuit astronomer Christoph Clavius, put it succinctly: "Annum civilem necessario constare ex diebus integris" ("Civil years necessarily consist of integral days"). This basic requirement is the root of all the difficulties in the construction of an accurate calendar. It is also primarily why the creation of a perfect calendar, one that would never err by even a single day, is impossible.

In principle the Gregorian calendar is merely a slightly altered version of the Julian calendar. The commission decreed that 10 days would be eliminated from the year 1582 in order to restore the date of the vernal equinox to March 21; over the many centuries the date had regressed to March 11. To curb the drift of the equinoctial date a plan was adopted whereby in three out of every four centurial years—for example 1700, 1800and 1900—the leap day that would have been added in the Julian system would henceforth be omitted. These revisions, promulgated in the papal bull of February 24, 1582, set off a wide barrage of polemics, incited furious debate among scholars and prompted the man in the street to question whether birds would now know when to fly south for the winter. One merely has to leaf through the great *Bibliographie Générale de l'Astronomie* published in 1887 by Jean-Charles Houzeau and Albert-Benoit Lancaster to gain an idea of the enormous number of treatises that were written for and against the reform.

The controversy was as much religious as it was academic. This was the age of the Reformation; Protestant countries rejected the new calendar, denouncing it as a papal scheme to bring their rebellious fold back under the jurisdiction of Rome. The accusation was not entirely unfounded. Gregory XIII was a vigorous—in fact, a ruthless—promoter of the Counter Reformation. He assisted Philip II of Spain in his scourging of the Protestant Dutch and gleefully accepted the head of the leader of the French Huguenots after the infamous St. Bartholomew's Day Massacre, a blood bath that the pope celebrated as a Catholic victory, ordering a medal struck in its commemoration. Gregory probably saw it as an opportune time to impose a calendar reform on the Christian world, which he did by threatening to excommunicate anyone who refused to accept it.

Opposition to the calendar was not entirely a consequence of the religious strife of the day. Many learned men acknowledged the need for calendar reform (the accumulating error of the Julian calendar had been observed for centuries), but they were not persuaded that the Gregorian system was a significant advance over the "Old Style." Indeed, the preeminent mathematician François Viète, often called the father of modern algebra, condemned the reform as a corruption of the Julian calendar.

Leading scientists of the 16th century, Viète among them, argued that the Gregorian calendar was astronomically unsound. This opinion was shared by two of the bitterest critics of the reform, Michael Maestlin and Joseph Justus Scaliger. Maestlin, an astronomer, was one of the first to openly espouse the Copernican theory and is famous for having been Johannes Kepler's professor at Tübingen. Scaliger, also a renowned academic, was an extraordinary scholar; fluent in a dozen languages, he was a classicist, historian, philologist and chronologer. Colleagues called him a "sea of sciences," a "bottomless pit of erudition." He became an archenemy of Clavius, the principal defender of the Gregorian reform.

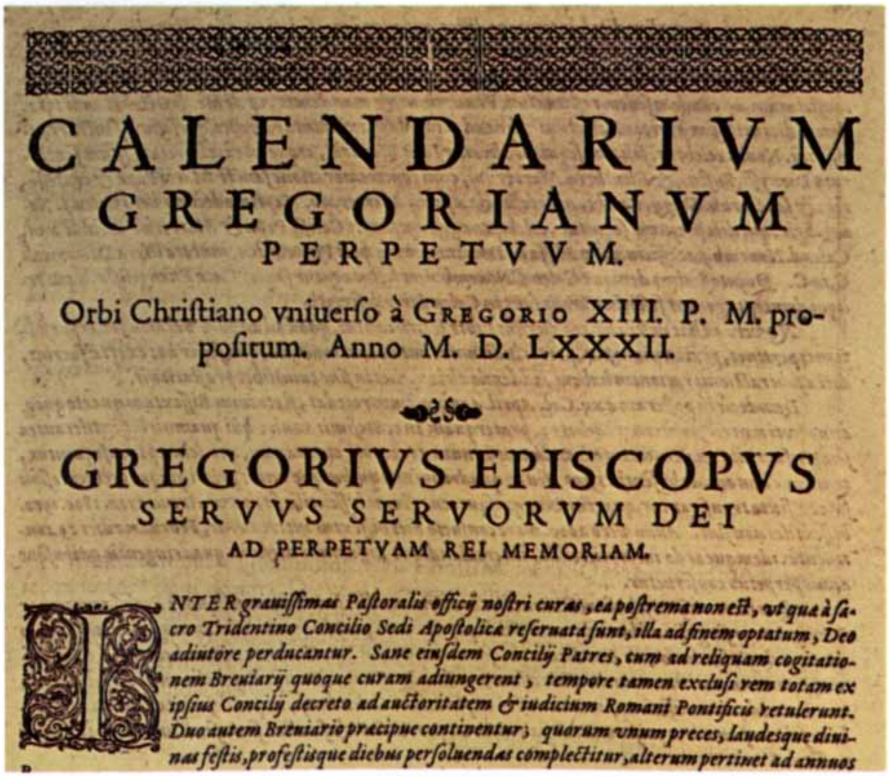
In 1595 Scaliger published a commentary on the *Canon Paschalis* of Hippolytus, a fourth-century work on the reckoning of the date of Easter. To it he appended a pungent criticism of the Gregorian calendar that is more than twice the length of the main work. Scaliger argued for his own plan of reform, which in fact would have produced a slightly more accurate calendar but a somewhat more complex one.

Clavius was quick to respond to Scaliger's pronouncements. In the same year he published a stinging rebuttal, *Iosephi Scaligeri elenchus, et castigatio calendarii Gregoriani*. Scaliger's criticisms from his work on the *Canon Paschalis* and Clavius' responses are presented in alternating paragraphs. Clavius' remarks are frequently amusing in their vehemence, but they are seldom more outrageous than Scaliger's invectives. He lashed out at the Bavarian Clavius, calling him a "German fat-belly" and a "beast."

Scaliger raised objections to both the civil and the ecclesiastical parts of the calendar. He maintained that the tables utilized in computing the date of Easter, called epact tables, were erroneous, and he protested that the reformed rules for observing leap years were not sufficient

DETAIL OF A PAINTING emphasizes the reason for the reform of the Julian calendar. A member of the commission appointed by Pope Gregory XIII in 1576 to study the need for reform is shown pointing to a chart indicating the 10-day error astronomers determined had accumulated in the Julian calendar since the time of the First Christian Council of Nicaea in A.D. 325. The upper arc in the diagram represents a segment of the calendar year divided into days, the lower arc a corresponding section of the tropical year (the year measured by successive passages of the sun through the vernal equinox). The zodiacal signs of Libra and Scorpio indicate the month of October, from which the 10 days in excess of the mean sun were to be removed. In the full painting the pope is shown sitting on a throne to the left. The painting is by an unknown artist whose work was commissioned in 1582, the year of the reform, by Scipio Turamini, a member of the municipal council of Siena. The photograph was made in the Archives of the City of Siena, which still has the full painting.

POPE GREGORY XIII is commemorated by a statue atop the entrance to the Palazzo Púbblico in Bologna. The portal was designed by the 16th-century architect Galeazzo Alessi to commemorate the pope's election because Gregory was born in Bologna. He became pope on May 13, 1572, and 10 years later instituted the reform of the 1,600-year-old Julian calendar.



CALENDARIVM
GREGORIANVM
PERPETVVM.

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

GREGORIVS EPISCOPVS
SERVVS SERVORVM DEI
AD PERPETVAM REI MEMORIAM.

INTER grauiſſimas Paſtoralis officij noſtri curas, ea poſtrema non eſt, vt quæ à ſacro Tridentino Concilio Sedi Apoſtolicæ reſeruata ſunt, illa ad finem optatum, Deo adiutore perducantur. Sane eiuſdem Concilij Patres, cum ad reliquam cogitationem Breuiarij quoque curam adiungerent, tempore tamen excluſi rem totam ex ipſius Concilij decreto ad auctoritatem & iudicium Romani Pontificis retulerunt. Duo autem Breuiario præcipue continentur; quorum vnum preces, laudesque diuinas feſtis, profeſtisque diebus perſoluendas complectitur, alterum pertinet ad annos

PAPAL BULL of February 24, 1582, ordered Christians throughout Europe to adopt the Gregorian calendar on October 15, 1582 (or in 1583). The bull was reprinted in Tome V of the *Opera mathematica* of Christoph Clavius, a Jesuit astronomer who was a leading member of the papal commission studying the calendar reform and later the principal defender of the reform. This photograph shows the first page of the bull as it appears in the Clavius volume.

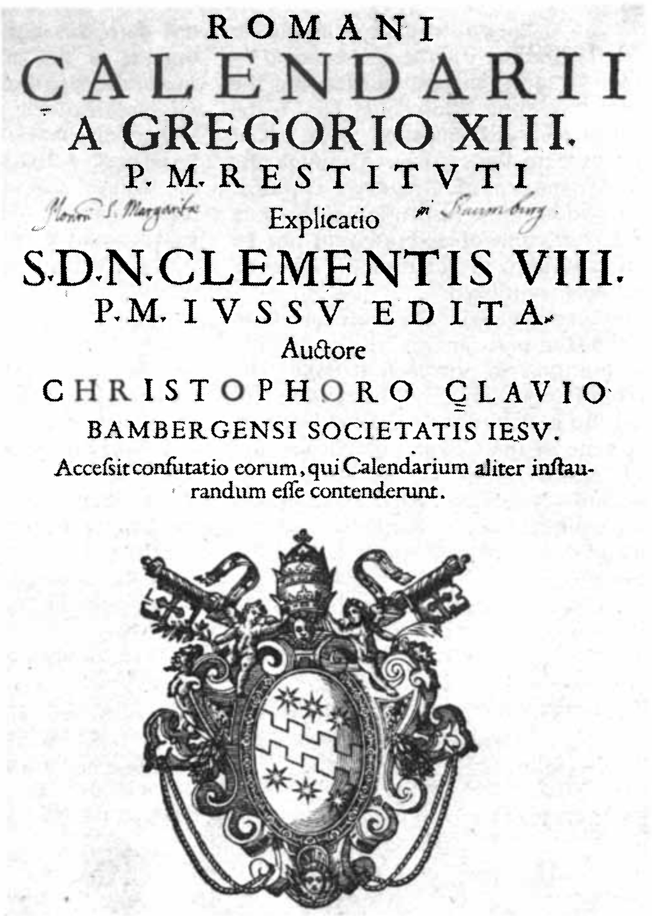
to keep the date of the vernal equinox consistently on March 21. Indeed, the calendar does embody a small fluctuation in the equinoctial date, amounting to a few days. Even so, the calendar succeeds in keeping the date on or near March 21 every year and will continue to do so for many centuries.

Maestlin, like Scaliger, did not approve of the Gregorian system for determining Easter. The Council of Nicaea in A.D. 325 had decreed that Easter should be celebrated on the same date by all Christians. It was decided by the church that the date should be the first Sunday after the 14th day of the moon (approximately the full moon) that falls on or next after the date of the vernal equinox, which at the time of the council was assumed to be fixed at March 21. The cumbersome rule is still applied today in establishing the date of Easter and subsequently all other movable feasts. Computing the Easter date is unquestionably the most intricate operation in the calendar. Even Carl Friedrich Gauss, who as a young man worked on the problem, did not succeed in developing a complete algorithm for deriving the date.

Easter can fall on any Sunday from March 22 to April 25 in any year. Incredibly, it takes 5,750,000 years for all the dates of Easter to repeat in the same order. The table of epacts is employed to determine the age of the moon on January 1 for every year in a cycle of 7,000 years. Since the average interval between one new moon and the next, called a lunation, is a little more than 29.53 days, the maximum number of epacts is 30 (29.53 rounded to the nearest whole number).

Knowing the moon's age on January 1, it is a simple matter to ascertain the dates of all the new and full moons throughout the year. It is then quite easy to find the 14th day of the moon occurring on or after March 21. The Sunday after the 14th day is Easter. The cycle of epacts, however, is only an approximation to the true or astronomical moons; an epact can differ by as many as three days from the actual lunar phase, although its usual deviation is only a day or two. The prime advantage of an artificial lunar cycle is its simplicity. The true motion of the moon is much too complex to reduce to a simple and convenient table, one that could be readily understood by clerics trained in the computus, the science of reckoning Easter practiced throughout the Middle Ages and the Renaissance.

Clavius was quite satisfied with close approximations. He repeatedly urged the need for simplicity in the calendar, noting that it was absurd to think everyone could be trained in astronomy. Nevertheless, Maestlin advocated the use of



ROMANI
CALENDARII
A GREGORIO XIII.
P. M. RESTITVTI
Explicatio
S.D.N. CLEMENTIS VIII.
P.M. IVSSV EDITA.
Auctore
CHRISTOPHORO CLAVIO
BAMBERGENSI SOCIETATIS IESV.
Accessit confutatio eorum, qui Calendarium aliter instaurandum esse contenderunt.

CHRISTOPH CLAVIUS was portrayed in 1606, when he was 69, in an engraving (*left*) by Franciscus Villamoena. Clavius was a distinguished mathematician who staunchly defended the Gregorian reform. The title page of Clavius' definitive work on the calendar is shown at the right. The work was commissioned by Clement VIII, who became pope in 1592; he was the fifth pontiff following Gregory.

exact astronomical calculations in deriving the date of the paschal (Easter) full moon. Kepler, unlike his former professor, supported Clavius' reasonably accurate method of following the moon, declaring that "Easter is a feast, not a planet."

Largely through his tireless defense of the calendar Clavius earned for himself an honored place in the history of science, so much so that the largest crater on the moon is named for him. In all he wrote five defenses of the calendar. The first, published in 1588, was an answer to criticisms made by Maestlin. Clavius' definitive calendrical work, however, is an 800-page tome, *Romani calendarii a Gregorio XIII P. M. restituti explicatio,* first published in 1603. Much of his defense against Maestlin is repeated, often verbatim, in this later treatise.

Clement VIII, who became pope in 1592, had enjoined Clavius to explain and justify the new calendar to the Christian world. The *Explicatio* is the copious result. It is an imposing technical work. The Edinburgh scholar Alexander Philip, the author of one of the few substantial texts on the calendar in English, wrote that Clavius, "like a cuttle-fish," actually clouded his subject in "the ocean of ink with which he surrounded it." There is some merit to the criticism; Clavius is at times long-winded and repetitious, but he is seldom inaccessible, and other scholars have remarked on his readability. He was, in fact, one of the best-selling scientific authors of the late Renaissance.

All Clavius' treatises on the calendar were reprinted and collected in Tome V of his *Opera mathematica,* which was published in 1612, the year he died. Tome V also includes a reprint of the *Kalendarium Gregorianum perpetuum,* the official publication on the reform issued by the church in 1582 and written by the calendar commission under Pope Gregory. Also reprinted is the papal bull, "*Inter gravissimas* . . ." ("In the gravest concern . . .") of February 24, 1582, announcing to all the Christian princes that the new system would officially begin on October 15 of that year. It prescribed the removal of 10 days from the calendar: "In order therefore to restore the vernal equinox to its former place, which the Fathers of the Nicene Council put at XII Kalend. Aprilis [March 21], we prescribe and command as concerning the month of October in the year 1582 that 10 days inclusive from the 3rd Nones [October 5] to the day before the Ides [October 14] be taken away." Clavius and the other members of the commission avoided a disruption of the days of the week in this expulsion of days; Thursday, October 4, 1582, the last date in the Julian calendar, was immediately followed by Friday, October 15.

In his defense against Maestlin, Clavius explained that there was nothing mysterious about the choice of month; October simply included the fewest religious feasts and therefore an omission in that month was the least disruptive for the church. He also described it as the month that presented the fewest problems for business.

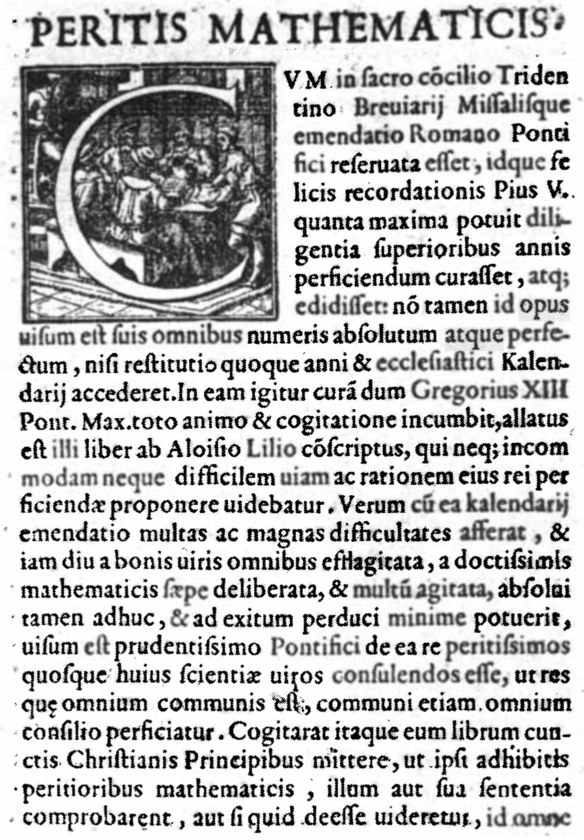
The elimination of 10 days was not an astronomical necessity. The date of the vernal equinox could just as well have remained at March 11. The real problem was in preventing whatever date was chosen from continuing to drift. How, then, did the plan enacted by Pope Gregory succeed in keeping the date on or about March 21? That is the central technical question to be asked in regard to the reform. Although the major concern of Gregory's commission had been the restitution of the date of Easter, that objective could not be achieved until the date of the equinox had been stabilized.

It is conceivable that no reform would have taken place in 1582 if the paschal celebration had not been at issue. The error of approximately 11 days that had built up in the Julian calendar between the time of the Council of Nicaea and 1582 was still a minor discrepancy that had not yet revealed itself as an appreciable difference between the days of the calendar and the seasons. In fact, if the Julian calendar had continued in use to the present, its error would be only about two weeks, still not large enough to be perceived in the Northern Hemisphere as a shift in the calendar dates of spring toward summer. Yet the error was significant in regard to Easter, since its observance depends on a fixed date of the vernal equinox.

The steady regression of the equinoctial date was almost entirely a consequence of the initial discrepancy between the length of the Julian year and the length of the tropical year. On the advice of the Greco-Egyptian scholar Sosigenes, Julius Caesar in instituting the Julian calendar in 45 B.C. established a plan whereby every common year consisted of 365 days and every year perfectly divisible by four consisted of 366. The extra day was originally added just before February 25, which was known as *ante diem sexto Kalendas Martius,* the sixth day before the calends of March. The extra day was therefore called *bissexto* [second six] *Kalendas Martius,* from which the term bissextile derives, a word still used to refer to the leap year and the leap day. In the Gregorian reform the leap day was shifted to the last day of February.

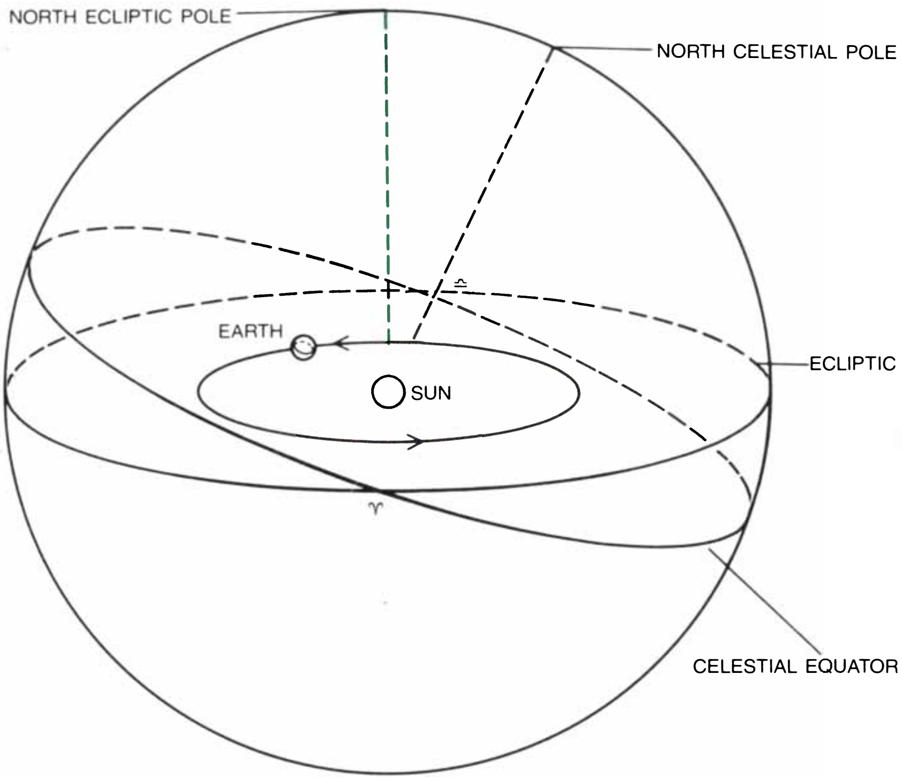
At the time of the inception of the Julian calendar the length of the tropical year was not a well-established quantity, at least not among Western astronomers. Sosigenes' plan for introducing an extra day every four years provided a mean calendar year of 365.25 days. In 45 B.C., however, the length of the tropical year was approximately 365.24232 days, or nearly 11 minutes four seconds shorter than the Julian year. This initially small discrepancy accumulated until the difference was no longer a matter of minutes but of days. It was then that the error began to reveal itself as a gradual regression of the dates of the equinoxes and solstices.

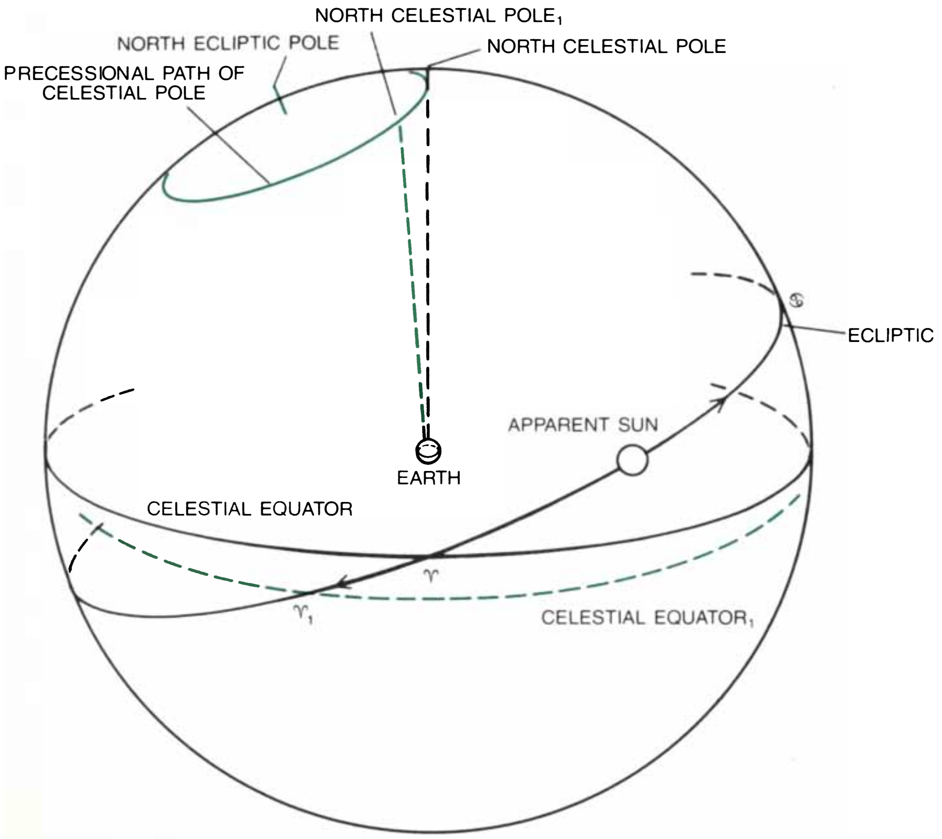
The accumulation of error on the Julian calendar was accelerated by the gradual decrease in the length of the tropical year, a phenomenon consistently ignored by scholars—even astronomers—treating the technical aspects of the calendar. The decrease follows a geometric progression that must be taken into account in computing the accuracy of a solar calendar. If the initial deviation between the Julian calendar and the mean sun had remained at 11 minutes four seconds (if the calendar had invariably gained that amount of time on the sun every year), the error would have amounted to one mean solar day in a little more than 130 years. The drift would have shown up as a shift of the equinoctial date back one calendar day from its position 130 years earlier. Actually, however, the regression of the dates of the equinoxes and solstices had been faster. By the time of the Gregorian correction the calendar was erring


PERITIS MATHEMATICIS.

CVM in ſacro cōcilio Tridentino Breuiarij Miſſaliſque emendatio Romano Pontifici reſeruata eſſet, idque felicis recordationis Pius V. quanta maxima potuit diligentia ſuperioribus annis perficiendum curaſſet, atq; edidiſſet: nō tamen id opus uiſum eſt ſuis omnibus numeris abſolutum atque perfectum, niſi reſtitutio quoque anni & eccleſiaſtici Kalendarij accederet. In eam igitur curā dum Gregorius XIII Pont. Max. toto animo & cogitatione incumbit, allatus eſt illi liber ab Aloiſio Lilio cōſcriptus, qui neq; incommodam neque difficilem uiam ac rationem eius rei perficiendæ proponere uidebatur. Verum cū ea kalendarij emendatio multas ac magnas difficultates afferat, & iam diu a bonis uiris omnibus efflagitata, a doctiſsimis mathematicis ſæpe deliberata, & multū agitata, abſolui tamen adhuc, & ad exitum perduci minime potuerit, uiſum eſt prudentiſsimo Pontifici de ea re peritiſsimos quoſque huius ſcientiæ uiros conſulendos eſſe, ut res quę omnium communis eſt, communi etiam omnium conſilio perficiatur. Cogitarat itaque eum librum cunctis Chriſtianis Principibus mittere, ut ipſi adhibitis peritioribus mathematicis, illum aut ſua ſententia comprobarent, aut ſi quid deeſſe uideretur, id omne

ORIGINATOR of the Gregorian calendar was Aloisius Lilius (the Latinized name of Luigi Giglio), who is portrayed at the left. On his death in 1576 his plan for the reform of the calendar was rescued from oblivion by his brother Antonio and presented to Pope Gregory XIII for review. The plan was adopted by the pope and his advisory commission with only a slight modification by Christoph Clavius. At the right is the first page of Lilius' compendium setting forth his plan for the calendar. The work was found by the author in the National Central Library in Florence, catalogued as being by an anonymous author, although the page reads, "This book written by Aloisio Lilio." The illuminated *C* depicts the pope presiding at a meeting of some of the members of his calendar-reform commission.





TROPICAL YEAR is the average interval between two consecutive transits of the apparent sun through the vernal equinox (*top*). The vernal equinox (♈) is the intersection of the ecliptic, the plane of the earth's orbit and the celestial equator (the projection of the terrestrial equator onto the celestial sphere). To an observer on the earth the sun seems to revolve about the earth (*bottom*). The sun at the vernal equinox moves along the ecliptic toward the summer solstice (♋) while the vernal equinox precesses in the opposite direction. After one year the sun has not made a complete circuit before it is again back at the vernal equinox in its shifted position (♈$_1$). Because of tidal friction the earth is gradually slowing in its rotation, resulting in a corresponding increase in the precession of the equinoxes. The consequence is that the length of the tropical year is diminishing gradually. The mean year of the calendar is 365.2425 days.

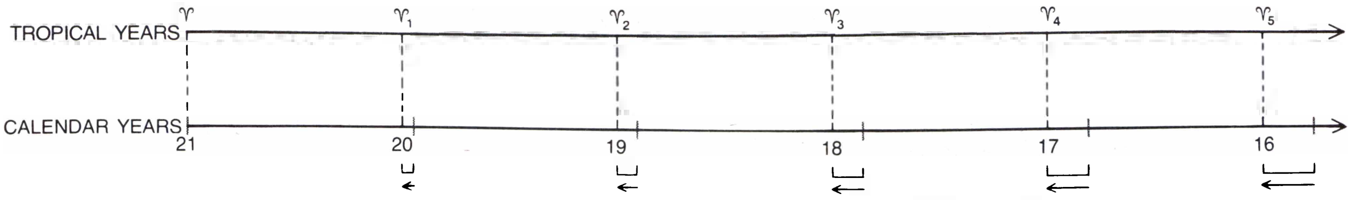
with respect to the mean sun at a rate of about one day every 128.5 years.

The decrease in the length of the tropical year becomes progressively more significant as a function of time. It is one of the circumstances precluding the construction of a perfect calendar. The main reason, though, as Clavius pointed out, is that a calendar designed for ordinary use must provide an integral number of days, whereas the tropical year has a complex fractional component. The matter boils down to trivial arithmetic: a fractional value can never be expressed as an integer. A solar calendar can only approximate the length of the tropical year; the fractional part is accounted for by intercalation, that is, the periodic insertion of intercalary, or leap, days in the calendar. The closer an intercalation approximates the fractional part of the tropical year, the more successful the calendar will be at retaining the vernal equinox at the same date over an extended period.

The plan of reform adopted by Pope Gregory meshes quite neatly with the Julian system and curbs the drift of the date of the equinox so effectively that the calendar will not lose a single day on the sun in well over 2,000 years. The plan that forms the basis of the Gregorian civil calendar was devised not by Clavius or any other member of the commission but by a lecturer in medical science at the University of Perugia, who unfortunately never lived to see his plan become law. His name was Luigi Lilio (often written Giglio), Latinized as Aloisius Lilius. Clavius called him the *primus auctor* of the new calendar. Before the calendar came to be generally known as the Gregorian it was often referred to as the Lilian calendar. Lilius not only developed the new intercalation for the commission but also constructed the table of epacts, which Clavius later modified to better conform to the new leap-year rules.

It was Lilius who recommended the removal of 10 days from the calendar, either all at once or over a period of 40 years beginning in 1584, by dispensing with the leap days that would normally be added every fourth year in that interval. Lilius left it to the commission to choose between these alternatives. Apparently it was Clavius who decided that the days should be extracted all at once from October.

Lilius labored on the details of his reform for some 10 years. The development of a convenient and fairly accurate method of reckoning Easter consumed most of his efforts. Far less of a problem was the construction of a system of intercalation that would better approximate the length of the tropical year. On his death in 1576 his *Compendium novae rationis restituendi kalendarium* (*Compendium of the New Plan for the Restitu-*



REGRESSION of the date of the vernal equinox results when the mean length of the calendar year is longer than the tropical year. Several vernal equinoxes are depicted. The first one falls on March 21, but over a period of time the discrepancy between the calendar year and the tropical year results in the regression shown by the brackets. For simplicity the gradual shortening of the tropical year is ignored.

tion of the Calendar), historically the most important document on the subject of the calendar, was presented in manuscript by his brother Antonio Lilio to Pope Gregory. It was then circulated for review among an international group of distinguished clerics and scholars. Lilius' work was praised for its accuracy and simplicity, and among the scores of proposals that had been offered it was clearly the one most favored for adoption.

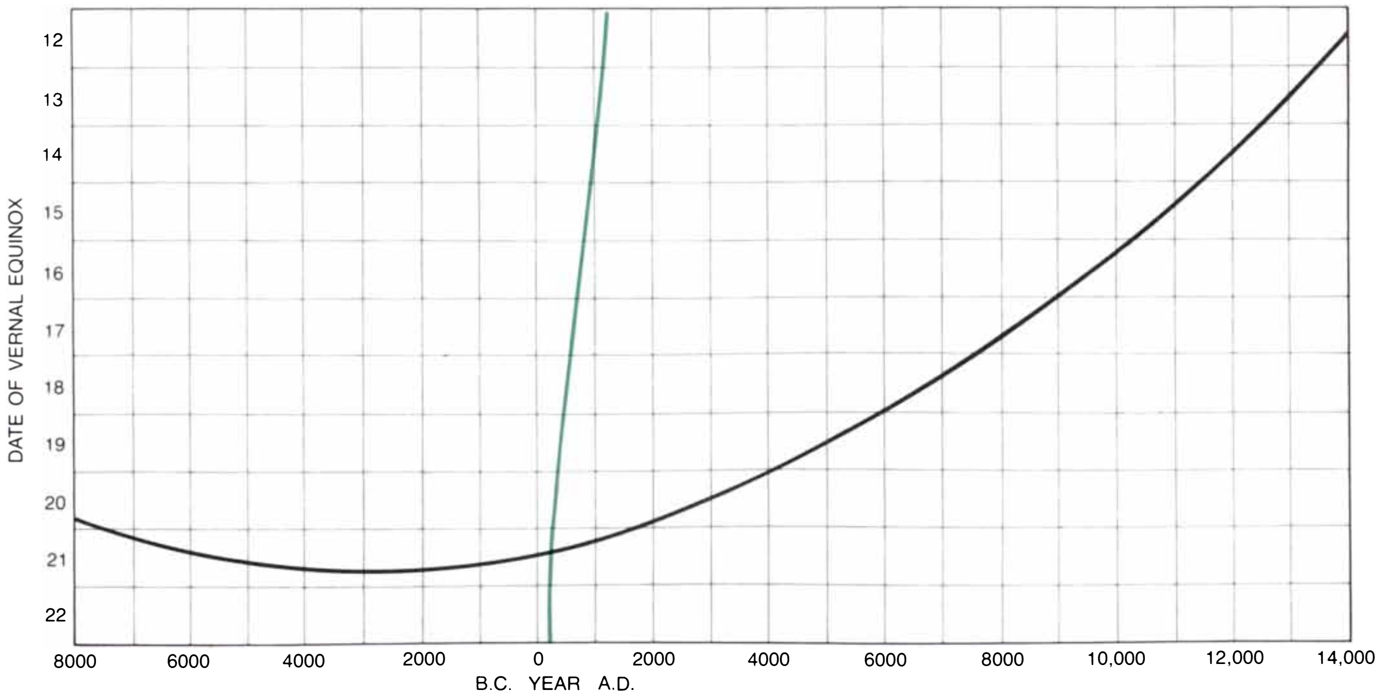
(In a note published in 1974 in *Journal for the History of Astronomy* Noel M. Swerdlow of the University of Chicago said it appeared that Lilius' treatise was lost. He added, "It is, however, not impossible that the *Compendium* survives still undiscovered in manuscript." Swerdlow recently wrote to me to say that Thomas Settle of the Polytechnic Institute of New York had learned that a printed version might be in the archives of the National Central Library in Florence. Indeed, a copy does survive in that library, where it is catalogued as being by an anonymous author. Yet on the first page of that slender volume Lilius explicitly states he is the author. Having confirmed the existence of the *Compendium* in Florence, I searched for it in a number of other Italian cities. The rare treatise, whose whereabouts is curiously never cited by scholars, is also in the archives of the Biblioteca Comunale degli Intronati in Siena and in the Vatican Library. Each library's copy is bound in a varying collection of separately published calendrical works by contemporaries of Lilius, the most notable among them being Alessandro Piccolomini.)

The intercalation Lilius proposed in the *Compendium* was simple: the suppression of three leap days in centurial years not perfectly divisible by 400. The Gregorian intercalation therefore follows the Julian system with the single exception that centurial years such as 1700, 1800 and 1900, which would have been leap years in the Julian calendar, became common years (with the leap day dropped). The Gregorian calendar reduces the number of intercalary days to 97 in 400 years, as opposed to 100 intercalary days in 400 Julian years.

The change is small but profound. It brings the mean length of the calendar year into much closer agreement with the tropical year, providing a mean calendar year of 365.2425 days. In 1582 the length of the tropical year was nearly 365.24222 days, which differed from the Gregorian year by only a little more than 24 seconds. If the length of the year itself were not gradually diminishing, the calendar under the plan devised by Lilius would retain the date of the vernal equinox at or about March 21 for more than 3,550 years.

Clavius himself estimated that the calendar would deviate by one day in the year 5084. Considering the decline in the length of the year, which was quite unknown to 16th-century astronomers, the calendar will remain accurate to within one mean solar day for a much shorter time, some 2,417 years, or until about the year 4317. (Extrapolations are based on the determination of the tropical year at epoch 1900 by the American astronomer Simon Newcomb; his figure was 365.24219879 mean solar days.)

How Lilius arrived at a value of 365.2425 days remains a mystery. Discouragingly the *Compendium* sheds no new light on the question. The most reli-



JULIAN AND GREGORIAN CALENDARS are compared with respect to the drift of the date of the vernal equinox. In the Julian calendar the drift (*color*) was quite rapid. In the Gregorian calendar it is slower (*black*) because the calendar more closely approximates the tropical year. The tropical year equaled the Gregorian year of 365.2425 days in about 3000 B.C. Since then the drift has accelerated.

able values of the tropical year known to Lilius were given in the *Alphonsine Tables* of 1252, Copernicus' *De revolutionibus orbium coelestium* of 1543 and the *Prutenic Tables* of 1551. Each source gives a value of about 365 days five hours 49 minutes 16 seconds; they differ from one another by less than a second, and yet all are approximately four seconds longer than the Gregorian year. None will produce an intercalation of 97 days in 400 years. Swerdlow recognized, however, that all three quantities expressed as sexagesimal fractions—the form in which they would be taken from a table of the mean motion of the sun—are identical with the second fractional place. The form of expressing the sexagesimal fraction is 365; 14, 33 (the second fractional place being 33). Converting the sexagesimal fraction into a common one gives $365^{97}/_{400}$, or 365.2425 days. It is as good a theory as any for the origin of the length of the Gregorian year.

Lilius was not the first to propose an intercalation of 97 days in 400 years. The same plan was put forward in 1560 by Petrus Pitatus, an astronomer of Verona. It is not known whether Lilius borrowed from Pitatus, but the intercalation is simple enough to have been derived independently.

Lilius' system confines the date of the vernal equinox within rather narrow limits. The date can be March 21, March 20 and even March 19, although it has not fallen on March 19 since about the turn of the century. Notwithstanding what is said in many textbooks on astronomy, the vernal equinox as a result of the Gregorian rules for leap year falls more often on March 20 than it does on March 21.

A consequence of the Gregorian intercalation is that all the dates in the calendar repeat in a cycle of precisely 146,097 days, which equals 400 Gregorian years. In other words, every date in 1583 will be repeated in 1983; the same is true for 1584 and 1984 and so on in multiples of 400 years. The calendar completes its first grand cycle on October 15 of this year.

Lilius and Clavius succeeded where others had failed. The Gregorian calendar affords a highly satisfactory compromise between essential accuracy and much-desired simplicity. For more than 800 years attempts to improve the Julian calendar were made by such able men as Roger Bacon, Nicolas of Cusa, Regiomontanus, Johannes Schöner and Paul of Middelburg. Each scholar had recorded the growing disparity between the calendar and the sun, but for one reason or another—including political strife, governmental indifference, untimely death—nothing was done about it until in 1572 a former professor of law from Bologna named Ugo Buoncompagni became Pope Gregory XIII.