Dionysius, Zero, and the Millennium: the Real Story

By Christian Marinus Taisbak

With the arrival of the year 2000, two questions have been asked frequently. First, when does the second millennium end, at the end of 1999 or at the end of 2000? Second, how "correct," with respect to the actual date of the birth of Christ, is the number of the year?

The answer to the first question is pretty clear. If somebody had inaugurated the Christian era from its very start, the first year of it would have been called "year 1", the second "year 2" etc. (The leaders of the French Revolution styled the years in just this way in their new calendar from the autumnal equinox 1792. Even though zero had been known and used for a long time, no one insisted on, or even considered, numbering the first Republican year "zero." In fact, see below for Dionysius and zero.) Years are intervals, not points on the number (or time) axis, and intervals are always numbered by the point to the right of the interval. The first mile of the way ends at the first milestone. Therefore the year 1999 started at point 1998 and ended at point 1999, and time will not pass point 2000 until December 31, 2000. We have (so to speak) reached page 2000, but not yet read it, so we still do not know whodunit.

So much for question one. But we all know that the Christian era is like a broken ruler that's missing 500 years at the beginning. It was not invented when it started. The Christian era was made up by one man, Dionysius Exiguus, who in the year *241 Diocletiani* (according to the calendar current at the time) sat down to calculate Easter tables for a ninety-five year period starting on 248 Diocletiani. To suit the Western Church, he decided to edit his tables in Latin and use dates in the Julian calendar, in contrast to his predecessors (and primarily one Cyrillus), who had done it in Greek and used the Alexandrian calendar. In his prefatory letter to his tables he writes

"... since [Cyrillus] ended his tables with 247 Diocletiani, mine ought to start at the year 248 since that despot. But I prefer to denote the years from the incarnation of our Lord Jesus Christ, the Beginning of All Our Hope..." (Migne, *Patrologiae Latinae* 67, 20).

And then, without much arguing, he changes numbers (and history) by equating 248 Diocletiani with anno Domini 532 — as if everyone knew that Jesus had been born 532 years before.

The date of Easter was set by the Council of Nicea as the first Sunday following the first full Moon that occurs on or after the Spring equinox on March 21. Hence, to calculate his tables, Dionysius needed to determine the position and phases of the moon on different dates. The procedure for doing so, known as the *computus*, was quite complicated.

To begin with, one needs to match up the lunar and the solar calendars. Dionysius probably used the *Metonic rule,* which says that 19 solar years equal 235 lunar months. The average lunation being 29.5 days, there was an agreement that lunations of 30 days end in odd months and lunations of 29 days in even months; if a short lunation happens to end in an odd month, an "embolismic" (leap) lunation of 30 days is inserted. Hence, the 235 lunar months break up into 114 lunations of 30 days alternating with 114 lunations of 29 days, with seven extra 30-days' lunations sneaking in as "embolismic" lunar months.[1]

Think of a year in which the age of the Moon is 2 (that is, the Moon is in the second day of its cycle) on March 24 (= 28 Phamenoth, the 7th month in the Alexandrian calendar. This date is chosen because the Moon has the same age on that day as on the Alexandrian New Year's Day, 1 Thoth). The previous full Moon was March 6, too early to serve as the paschal Moon, which must be on or after the equinox, March 21. The next full Moon is April 5, and Easter will be to first Sunday after that day.

[1] *Cf. W.E. van Wijk, Le nombre d'or, Nijhoff, Haag 1936, p. 5 ff. He also inspired the vital point of my thesis: that the year 532 was chosen "par raisons computistiques," ibidem p. 17.*

What will happen the following year? Since the normal solar year is 11 days longer than the lunar year, the age of the Moon will be 13 next year on March 24.[2] So the next full Moon is March 25, which — being after the Equinox — is the paschal Moon, and Easter Sunday will be on April 1 at the latest.

The Alexandrian computists called the difference between the age of the Moon at the beginning of the reference year and at the beginning of the current year, the "epact." In the example above, the epact was 11. In the third year the Moon gains another 11 days, so the epact is 22, which must be added to our initial 2, making the Moon 24 days old on March 24. But in the fourth year the epact amounts to thrice 11 = 33, and no moon ever grows as old as that; so we subtract 30 (in fact an "embolismic" month has sneaked in during the year), finding a 5 day old Moon on March 24. The previous full Moon was March 3, so the paschal Moon will be the next one, on April 2.

It is not hard to lay down a rule for calculating the epacts: In the first year nothing is to be added. In the second year the epact is 11. In year 3 it is twice 11; in year 4 it is three times 11, and so forth; whenever the sum gets greater than 30, that number is subtracted. In year N it is (N-1) times 11, modulo 30.

In the 19th year the epact is (18 times 11) modulo 30 = 18, so it should be 29 in year 20. But that's where the Moon "leaps" (the Mediaeval "saltus lunae"), so that the next 19 years the cycle can start with epact 30, that is: with zero, as Dionysius writes in his table.

Obviously, things would be easier if the number of the year is divisible by 19, that is, if the first year was no. 19 or 38 or 19*n* in some era, because then the epact rule will be epact = [11 times year (mod 19)] (mod 30). So I imagine Dionysius looking for a count of years that would make the first year of his new table a multiple

[2] *By some miraculous accident it is possible to ignore leap years, since the tiny fraction by which the average lunation is greater than 29.5 days "eats up" the quarter of a day each year.*

of 19. He knew (as did everybody else in the Church) that about half a millennium had passed since Pilate was prefect in Jerusalem. So it occurred to him that 532 after the incarnation of Christ would fit quite well, and would even make leap years (which that year was supposed to be) divisible by 4.

He would not have bothered about the precise date of the birth of Christ. December 25 had been chosen a couple of centuries earlier. He was thinking in the Alexandrian calendar, so there was no doubt about the counting of years. In the eras of sovereigns the first year is that in which they took over, thus "the first year of Diocletianus" started on August 29 (Thoth 1 in the Alexandrian style), even though he was not declared emperor until November 17. So the first year of Christ would be the one in which he was — at some time — born. Furthermore, it was not his birth, but his resurrection that mattered, March or April were the months to keep track of, and probably Dionysiyus never really thought of changing the dating system in his new era. The date of Easter during the coming 95 years was his problem. Did he believe in the 532? Who knows? But who was there to contest him? He certainly was considered an authority, and he needed his multiple of 19.

To find the Sunday following the paschal Moon one must observe that each year the date of Sundays moves one day, in leap years two days. Dionysius (like his predecessors) noted the dates of March 24 in a table of "concurrentes", running days, in a 28-year scheme, as follows (1 meaning Sunday): 4, 5, 6, 7, 2, 3, 4, 5, 7, 1, 2, 3, 5, 6, 7, 1, 3, 4, 5, 6, 1, 2, 3, 4, 6 , 7, 1, 2. He makes little noise about this cycle, so that one might think he did not really see its significance. But of course he did, 532 being 28 times 19.

If this reconstruction is right, the question of the correctness of our year numbering becomes meaningless. The count is chosen arithmetically, not historically, to make the computations easier.

Many attempts have been made in the last few years to save the Big Bang in honour of 2-and-Three-Zeroes. Even the year Zero has been dragged in, "forgotten or unknown by the stupid monk Dionysius Exiguus." That he not only knew his zeroes, but in a way invented them for calendric purposes, can be seen from his tables, where he indicates that the epact is zero for the Anno Domini 532. There's no way of avoiding it: the millennium ends on December 31, 2000. But the 2000 isn't really 2000 years after any particular historical event. Rather, it's the result of Dionysius' making sure that his computations went well. ■

Christian Marinus Taisbak, who completed this article on "vi Idus Februarias MM," retired from a Chair in Classical Philology at Copenhagen University in 1994 and is now Reader in History of Ancient Mathematics at the same university.

Two selections from Dionysius' tables, with commentary

First, the last entry in what he pretends to be Cyrillus' table:

Anni Diocletiani	CCXLVII	of Diocletianus' years 247
quae sint indictiones	VIIII	indictio 9 (in a 15 years' cycle)
epactae, id est adiectiones lunae	[XVIII]	epact = 18 (scribal error corrected)
concurrentes dies	II	weekday no 2 (March 24 = Mon)
...		
quae sit Luna XIIII Paschalis	XV kal. mai.	Easter Full Moon April 17
dies Dominicae Festivitatis	XII kal. mai	Easter Sunday April 20

Then the first entry in his New table:

Anni Domini	DXXXII	A.D. 532 (leap year)
quae sint indictiones	X	indictio 10
epactae, id est adiectiones lunae	nulla	epact = zero!
concurrentes dies	IIII	weekday no 4 (March 24 = Wed)
...		
quae sit Luna XIIII Paschalis	non. april.	Easter Full Moon April 5
dies Dominicae Festivitatis	iii id. april.	Easter Sunday April 11