evident in Martianus. Forced to rely on defective secondary sources, Isidore of Seville (d. 636) a century later nevertheless attempted a compilation of universal knowledge, the *Etymologies.* It defines any four-sided plane figure as a square and a cylinder as a square figure with a semicircle above it. Notwithstanding its mathematical weakness, one cautious modern historian has called the *Etymologies* "one of the outstanding feats of scholarship of all times."[302]

Despite their shortcomings, these handbooks are ancestors to the survey textbook, legal brief, and scientific resumé. After Roman neglect, they helped restore teaching of the quadrivium. Boethian arithmetic preserved the ideal, as distinct from the model, of a theoretical science when the urban culture of the Latin West had so crumbled that advanced mathematics was incomprehensible there.

Urban populations exposed, among other things, to new diseases carried from Asia dropped precipitously: in the sixth century not one of the once populous Western cities had 20,000 residents and many cultivated fields were abandoned. Early medieval Europe had become rural and dependent on Benedictine monasticism for cultural cohesion. In 529 St. Benedict, a former aristocrat turned hermit, founded a monastery at Monte Casino between Naples and Rome. Monks ("solitary") had practiced ascetic Christianity in Egypt and Syria. Benedict's contribution was to channel their diffused energies into a regulated life of common prayer, work, and meals under a paternal abbot. His rule was strict but moderate, enjoining propertyless celibacy and silence, permitting a siesta and ration of wine, and encouraging hospitality. Successors to cities, economically self-sufficient abbeys spread rapidly. Monastic labor kept alive building and craft skills and improved agricultural techniques and empirical medicine.

Monastic prayer was tied to the calendar. Its pivot was Easter, a moveable date determined by lunar movements. Around it sacred cycles of the ecclesiastical or vulgar year revolved. Forecasting the correct date of Easter was inexact and spawned controversies during the seventh century. Benedictines looking to Rome observed one date: Irish monks drawing on an Alexandrian (that is, Dionysian) Greek tradition sometimes observed another. In Northumbria, where Celtic and Roman influence mingled, King Oswy (d. 671) was banqueting for Easter, while his Kentish-born queen was fasting and observing Palm Sunday.[303] This calendar crisis had been brewing underground for some time and its surfacing prompted the king to ask church authorities to convene the Synod of Whitby in 664.[304] The calendar difference arises since dating depends upon solar and lunar movements that are incommensurable. With a strong sense of order and concord but without benefit of astronomical and mathematical understanding, the fathers imposed the Roman reckoning based on the Dionysian cycle of 19 solar years and 235 lunar months.[305]

In 725 Bede (673–735) called "the Venerable," an Anglo-Saxon monk at Jarrow near Newcastle in England and the foremost western intellectual of his time, wrote the first reliable text of computing procedures to fix the date of Easter. Bede was so bookish that he described the ancient Roman wall, an

easy walk from Jarrow, by means of classical authors without archaeological inspection. Jarrow's library was large for those times, and Bede enjoyed a rare fluency in Greek, as well as mastering Celtic sources. Theodore of Tarsus, a refugee Greek monk who was archbishop of Canterbury, had introduced him to Greek and brought valuable manuscripts and "church arithmetic" (probably the Byzantine *computus*) to Britain. Bede's *De Temporum Ratione (On the Reckoning of Time)* addresses a branch of monastic study called the *computus.* The book combines mathematical rules and tables with descriptive astronomy, records, and chronological materials. Before the *Reckoning,* about six hundred Irish monks had used these multiple sources, probably assembled in Spain, to align the lunar and ecclesiastical or vulgar with the civil and solar calendar.

To determine the number of lunar months in a solar year, we now divide 365.2422 (days in a solar year) by 29.5306 (days in a lunar month) to obtain 12.3683. The decimal fraction 0.3683, representing the part of a lunar month that a calculator must add at the end of any solar year to align it with the lunar, can be approximated by the common fractions $3/8$, $4/11$, and $31/84$, and most accurately by $7/19$ ($= 0.3684$). Thus 3 lunar months intercalated into an interval of 8 years, 4 into an interval of 11 years, 31 into 84, and 7 into 19 will align the two calendars essentially as accurately as was possible. Although Meton had defined the 19-year cycle in Athens five centuries before the Christian era, monks confusedly used all the cycles in combination. Computists also disagreed about the time at which a lunar month began and the date of the spring equinox.

Working as a textual scholar, Bede compared about three hundred documents, untangled existing mathematical inconsistencies, and recovered essentials of the Dionysian cycle intercalating procedure, which requires subtracting the *saltus lunae* or one day near the end of the lunar cycle. Dionysius had extended the 19-year cycle to 95 years, and others had made it a 532 cycle (19×28), which Bede calls the great paschal cycle. To give added weight to his findings, he reported that the angel Pachomius had dictated the method for calculating Easter. Still, he knew that Dionysian reckoning produces discrepancies, for example having the the solar eclipse of 664 occur on May 3 instead of May 1, but further calendric improvement was not achieved in the Latin West until the eleventh and thirteenth centuries.[306]

Interested in chronology as well as *computus,* Bede sought to unify astronomical and historical time and successfully campaigned for a second calendar reform to replace localized regnal dating by the now universal dating of events from the year of Christ's birth. Other scholarly interests of Bede included metrology (whose units doubled as fractions) and finger counting, for which he gave the first written description.[307] This orally transmitted method permitted the calculator to record a subtotal temporarily while doing mental arithmetic. Monks calculating the Easter date needed a way to record intermediate results, and this method also supplemented reckoning on the *abacus* counting board. Finger counting, although unwieldy, implicitly incorporates a place-value system with the capability of computing up to values of 9999. Beginning from