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Time and Timekeeping

A General Overview

Timekeeping can be said to be a human universal. The British historian of science G. J. Whitrow in his book *What is Time?* traced a sense of time back to prehistory, hypothesizing it as derived from music and observation of nature: "A highly developed sense of rhythm enabled a tribe to function with precision as a single unit both in war and in hunting. Time is experienced by man in the periodicity of his own life as well as in the periodicity of the natural world" (Whitrow 1972, 4). Nonetheless, human societies have developed separate and sometimes very different means of reckoning time, as well as ascribing different imports to this reckoning.

The development of a sense of time and timekeeping in medieval Europe, in both its intellectual and its practical aspects, is striking both for its debt to antiquity and for the unique innovations birthed by physical, social, and theological necessity—innovations that, in turn, influenced the intellectual, economic, and legal spheres. These included ideas of cyclical and linear time; the religious use and conception of time; the historical use of time in chronicles and legal documents; timekeeping, both natural and artificial; and the birth of the equal hour, which in turn affected both the social use and natural philosophy of time. We will therefore begin with the macrocosmic concerns of theology and natural philosophy, and then turn to the social use of time and, finally, the development of the mechanical clock and modern timekeeping regimes.

B Theology and the Natural Philosophy of Time

I Theological Time

Christian theology, positing the immortality of the soul; holding to a cosmology that began with Creation and will conclude with Judgment; and believing in an eternal and unchanging deity that nonetheless entered historical time in the person of Christ, existed in dynamic tension with classical philosophy on time and eternity. It is thus not surprising that Christian ideas of time provided grist for theologians. In his *City of God* XII, 13, Augustine specifically refutes the cyclical nature of time, and then states (XII, 14) that humanity was created in time without

affecting God's omniscience or eternal, unchanging nature. In XII, 15, Augustine places the creation of angels—transcendental omniscient beings whose awareness encompasses all times—as posterior to God but prior to the creation of the heavens. Moreover, since angels are changing creatures subordinate to the Creator, he makes this creation the beginning of time. This then leads into a discourse on whether, since the creation of the angels began time, they cannot be said after all to be coeternal with (and thus equal to) God.

Interestingly enough, it is in the *Confessions* (ca. 397) that Augustine presents the nucleus of his thought on time. In XI, 6–8, he raises the question of how an eternal and unchanging God could speak to create the heavens and the earth, since that would involve action and therefore change. The answer, as anyone familiar with the Nicene Creed knows, is through Christ, the Word of God, who is coeternal with the Father and the Holy Spirit. He thus reconciles an eternal and unchanging God with a notion of creation in time and a Savior who works in human history.

In his *Consolation of Philosophy* (ca. 525), Boethius explains that lived time is a continuum that "proceeds in the present from the past into the future," but eternity embraces all moments. Intelligible time only exists in relation to eternity —which, being infinite, is unknowable (V, 6). Boethius obviated the problem of the eternity of the world by making a distinction between time, or *tempus*; the *aevum*, a temporal thing whose existence is drawn out infinitely (i.e., a soul, which, though it has an origin point, is immortal); and *aeternitas*, a truly eternal thing that embraces all moments at once. For our purposes, Boethius's significance is that he established the orthodox view that would be inherited by medieval thinkers, and which would have to be reconciled with the Aristotelian view: that time and eternity are incommensurate, a concentration on eternity as an aspect of the Divine, and a lack of concern with the metric of time.

II Time in Scholastic Philosophy

This orthodox view of theological time was shaken by the reintroduction of Aristotle's *Physics* in the twelfth century. The *Physics* was the primary work to inform this new medieval philosophy on time, and, in turn, later scientific conceptions of time. In a sense, the *Physics* can be seen as a work entirely about time, dealing as it does with the properties of bodies in motion, which might be better understood in the Aristotelian sense as "change in accidentals," or properties. First, in IV, 10, Aristotle raises many issues, pointing out that there is a plurality of opinion on whether time exists, whether it is infinitely divisible, and if there is such a thing as the "now." He holds that time is not change itself, since

change is measured in terms of time. Nor is it the heavenly sphere, for even a portion of the rotation of the heavens is time, and besides, if there were a plurality of heavens, the movement of each would be time. In IV, 11, Aristotle says that without motion, there is no perception of time; however, time is not motion, since if we are in darkness, sensing nothing with our bodies, our minds or souls (*anima*) still perceive time. Time, like magnitude, is a continuous quantity. Furthermore, things that stand still are still in time. Time is therefore not motion, but neither does time exist without motion. Finally, Aristotle concludes that time is nothing more than the "number of the motion with respect to the before and after"—in James of Venice's twelfth-century Latin translation, *numerus motus secundum prius et posterius*.

The attempt to reconcile the neo-Platonic and the Aristotelian positions, and to theoretically defend the growing science of timekeeping, would fill many Scholastic manuscripts. As Richard C. Dales has summarized the intellectual problem: "If the eternal is not subject to time but exists *tota simul*. ... how is the term 'duration' to be understood at all with respect to that whose mode of existence is non-temporal?" (Dales 1988, 27). Dales suggests that reconciling these theologically necessary positions became a topic of contention in the thirteenth and fourteenth centuries, fueled by the universalizing Scholastic impulse to reconcile all worldly and supernatural phenomena under the divine plan, and causing an entire vocabulary of eternity and duration to be invented in the twelfth century. Roland J. Teske, on the other hand, has countered Dales' opinion that this scholarly explosion was a result of refinement of intellectual problems within the body of patristic thought, using the writings of William of Auvergne as his counter-example: "...it was only, it seems, when the Aristotelian doctrine of the eternity of the world was thrust before the Christian thinkers of the West and when the problem of two senses of 'eternity' was realized that there was a pressing need to reach some clarity on the topics of eternity and time" (Teske 2000, 125).

Likewise, the increasing emphasis on astronomically-based chronological measurement from the eleventh through the thirteenth centuries (see below), required a re-evaluation of the possibility of time-measurement. Commentaries on Aristotle provided one medium for this discussion. For instance, Richard Rufus of Cornwall (2003) in his commentaries on the *Physics* composed ca. 1235 includes Aristotelian arguments on the objective reality and measurability of time. Similarly, in Robert Kilwardby (Lewry, ed., 1987) we find explicit references to objective measurement. Alain Boureau goes so far as to argue that "we find with Kilwardby the first speculative defense of the quantification of time by instruments" (Boureau 1998, 41). Roger Bacon, ca. 1267, gives the epitome of the realist position on time: time is independent, unitary, is abstracted from and does not adhere to individual things, and flows without reference to moving things,

though we can know of its passage from moving things. Bacon gives an additional, theological proof of this, using the doctrine of transubstantiation: just as there is no moment in which the Host is *partially* bread and *partially* the Body of Christ, but rather the whole is accomplished, so, too, can there not be two times. Moreover, astronomy is the most sure judge of time. Bacon then goes on to tell us there were precisely 2226 years, one month, 23 days, and four hours between the creation of Adam and the Flood (Brewer, ed., 1859, 142–46 and passim, 208).

Thomas Aquinas, by comparison, is much less concerned with the metric of time and motion, and more with an Augustinian idea of the perception of time being a witness to the existence of God. As Helen S. Lang remarks of his *Physics* commentaries, Aquinas's sense of "physics starts out from mobile things as an effect in order to reach the first cause of motion in the universe, the unmoved mover of *Physics* 8, whom Thomas identifies with God" (Lang 1992, 164).

Pierre Duhem in his *Le Système du Monde* famously wrote that the first, most important step toward the conceptualization of an absolute, evenly-flowing, Newtonian sense of time was taken in 1277, when Étienne Tempier, Bishop of Paris, prohibited (at papal prompting) the teaching of 219 propositions debated in the University—most significantly, condemning in articles 80–89 the proposition that God could not accelerate the universe in a straight line (as the universe would then leave a vacuum behind it, an Aristotelian impossibility), as well as the proposition that God could not have created a multiplicity of worlds, had He so wished (Duhem 1956, 439–41). Rather, Tempier decreed, God could have created other worlds beyond the outermost sphere of fixed stars and moved the whole Ptolemaic universe which we inhabit into an outside space beyond and between these spheres. As Milič Čapek has summarized, "This space received the name 'imaginary space' (in contradiction to the 'real' space contained within the celestial spheres), and in analogy to it the concept of *imaginary time* was formed. Thus in order not to confine the divine power within the limits of the finite Greek universe, the first departure from the Aristotelian relational theory of time was made... the first step toward a separation of time from its physical content—which is the very essence of the absolutist theory of time—was made" (Čapek 1987, 607–08).

An equally compelling case, however, might be made for the effects of the nominalist turn and the invention of the mechanical clock on the theorization of time. The arch-nominalist William of Ockham, living at the dawn of the age of the mechanical clock, defined the essence of time to be the very act of "telling time." The pressing question for Ockham was what is this known thing, the "better-known measure," against which we compare time? Ockham answers that the outermost heavenly sphere, the *primum mobile*, is the absolute guide by which the motion of every other body is known (including the sphere of the stars). As

Herman Shapiro summarizes, "'Time,' for Ockham, is a connotative term signifying directly the motion of an *absolute existent*—i.e., the prime mobile—and consignifying the soul which imparts number to this motion" (Shapiro 1957, 111, n. 274).

Those who followed Ockham, such as Jean Buridan, followed this conception. "Because only the first and most regular motion is properly called 'time,' it is only the motion of this outer sphere that is time in the first and most proper sense," as Dirk-Jan Dekker has summarized Buridan's position (Dekker 2001, 155). Nonetheless, Buridan also displays some discontinuities, for instance, in this idea of time as an independent metric that did not rely on a soul to perceive it. According to Dekker, time for Buridan "is a successive thing (*res successiva*) and is thus identical to motion"; "... time signifies the same as 'motion'... and is applicable as a measure"; and "[t]he existence of time does not depend on an activity of the intellective soul" (Dekker 2001, 152).

Buridan's student Nicole Oresme introduces other hallmarks of modern thinking on time, such as introducing the metaphor of the clockwork universe in his *De Caelo*, written between 1372 and 1377 (Clagett 1968, 6–7, n. 10). In the same work, Oresme also introduces the "traveller's dilemma": suppose one of three priests sets out from a central point eastward along a road that goes around the entire earth; his colleague sets out westward along the same road; and the third stays at home. Both travelers circumnavigate the globe and come back home on the day that the stay-at-home-priest celebrates Easter. However, the priest traveling westward has counted ten days, while the one traveling eastward has only counted eight days! Time is, therefore, an independent thing from any observed physical phenomenon, even if we *tell* time by such things—an opinion Oresme makes clear in his *Physics* commentaries. Clearly, over the course of the thirteenth and fourteenth centuries, a break from both the agnostic Augustinian orthodoxy of the unknowability of time and the development of a position indistinguishable from the "independent world of mathematically measurable sequences" that Lewis Mumford (see below) identified with Newton and modernity (Mumford 1934, 15).

III Christianity, Judaism and Islam: the Lunar Calendar in a Solar Calendar World

It is no coincidence that Oresme chose to use the date of the celebration of Easter to make his point about the relationship between time and observation. In addition to the importance of contemplating the nature of time for the philosophical underpinnings of medieval Christianity, the importance of practical timekeeping

for cultic practice in medieval Europe ought not to be underestimated. A great deal of intellectual energy was expended on chronological matters, particularly with regard to the delineation of the year, owing to the perceived necessity of accurately calculating the days on which particular festivals fell. The three Abrahamic faiths that dominated medieval Europe (Christianity, Islam, and Judaism) operated three separate calendars. The oldest of these three was the Jewish lunisolar calendar, which is divided into twelve lunar months (the amount of time it takes the moon to rotate around the earth [approximately 29.5 days]) that run from new moon to new moon and an additional thirteenth 'embolismic' month, which is inserted to ensure that the lunar calendar synchronizes with the solar year. In contrast, the Muslim calendar is purely lunar, being divided into twelve lunar months. Thus, there are approximately 33 Muslim years in every 32 solar years (Freeman-Grenville 1995, 2–4).

As in so many other aspects of Christian culture, Christian chronography was heavily indebted to its Jewish and Roman antecedents. The Christian year is centered on the celebration of two main feasts: Christmas (which is fixed in the solar calendar) and Easter (which is moveable and dependent upon both the solar and lunar calendars). The most important of these was Easter, a celebration both of the resurrection from the dead of Jesus and the potential salvation of men more generally, and methods used to determine the correct date on which to celebrate Easter were the cause of major controversies within late antique and medieval Church and society.

It is hardly surprising that the method of calculating the date of Easter Sunday should have been vigorously debated, when even fundamental aspects, such as the celebration of Easter upon Sunday, were not universally agreed upon in the early Church. One early Christian sect, the Quartodecimans, celebrated Easter on the fourteenth of the Jewish month of Nisan, regardless upon which day of the week it fell. The Quartodecimans could claim apostolic authority for so doing and such scripturally derived authority was at the heart of the issue, owing to the general acceptance that orthodoxy in belief was outwardly manifested through uniformity in ritual. Scriptural authority for liturgical practice was the same as that for belief; it followed, therefore, that a refusal to follow the liturgical customs sanctioned by scripture displayed the same attitudes that encouraged doctrinal heresy (Charles-Edwards 2000, 413). Unfortunately, the holy books were not prescriptive; they contained ambiguities and were in places contradictory and so their texts had to be interpreted and rules construed from them. Political pressures (and expediencies) frequently featured in the various attempts to overcome Easter controversies, such as Constantine's demand for unity of practice at the Council of Nicaea or the political machinations surrounding the Synod of Whitby in seventh-century Northumbria (Mayr-Harting 1991, 101–13). Indeed,

within individual kingdoms the celebration of separate Easters could seriously disrupt the communal life of royal courts and by extension society as a whole (Holford-Strevens 2010).

By the third century most Christians agreed that Easter should fall on the Sunday after *luna XIV* (the fourteenth day of the first lunar month of spring), but agreed on very little else, except that the date was to be calculated, rather than based upon celestial observation (Blackburn and Holford-Strevens 1999, 801). Various traditions developed regarding the day upon, and the chronological limits within which, Easter should fall. In the middle of the fifth century Victorius of Aquitaine produced his popular Easter table, which ran in a cycle of 532 Easters, but problems with his methods resulted in the papacy commissioning another system of calculation, by Dionysius Exiguus, in the sixth century. Both were widely used in Western Christendom (alongside other systems, such as the Irish and British *Latercus*) and it was the eighth-century Anglo-Saxon author Bede who eventually secured the triumph of Dionysius over Victorius (Blackburn and Holford-Strevens 1999, 796). The methods for calculating Easter were generally based on increasingly good mathematics and ever worse biblical exegesis, with the latter taking precedence over the former (Charles-Edwards 2000, 395–96). In addition, the prioritization of calculation over astronomical accuracy led to such farcical situations as that of 664, when Dionysius's table placed the new moon on the 4th of April, Victorius's on the 3rd of April, and the *Latercus* on the 30th of March—whereas the new moon actually occurred on the 2nd of April (Blackburn and Holford-Strevens 1999, 706). Muslim Europe was blessedly free of such manmade problems; the Muslim calendar worked upon an observational principle, in which a new month did not begin until the new moon was perceived in the sky and calculations were, strictly speaking, merely a guide (Freeman-Grenville 1995, 4).

Despite victory for the adherents of the Dionysian system in the eighth century, the matter was far from forgotten and study of *computus* (the science of calculation and the texts themselves) continued to be an important intellectual activity in Ireland (Ó Cróinín 2010) and indeed much of Europe during the subsequent centuries, as witnessed by the computistical writings of men such as Abbo of Fleury (tenth century) (Pfaff 2004), Roger of Hereford (twelfth century) (Burnett 2004), or Marianus Scotus of Mainz (eleventh century), who used his computistical knowledge to create a substantially new chronology for his universal chronicle (Verbist 2002).

C Historical Time in the Middle Ages

I Chronicle Writing and Identifying the Year

A key factor in historical chronology is the identification of the year, which allows events in one year to be catalogued together and relative chronologies to be established. Identification of the year (whether solar or lunar) could be achieved through a variety of systems. During the Roman Republic and Empire the year was usually identified by reference to the name of the holders of the consulship. The result of this eponymous system was that long-term dating could only be as accurate as the consular lists upon which it was based. Cyclical dating systems, such as the financial fifteen-year cycle of Indictions instituted by Constantine the Great, provided fixed points of reference only within each cycle. Cyclical systems, like the Olympiads (the ancient Olympic Games' quadrennial cycle) and in particular the Indictions, continued to be used frequently in the medieval period, long after they lost their original function in the West. Increasingly popular in the medieval period, however, was the use of regnal years (dating to a particular year in a ruler's reign), which did not begin in the Empire until the reign of Justinian in the sixth century. Regnal years generally ran from an anniversary to the day preceding the following anniversary, though the anniversary in question could be that of the ruler's accession (as practiced by the Byzantine emperors and Merovingian kings) or coronation (as practiced by the later kings of France, Holy Roman emperors, and popes) (Blackburn and Holford-Strevens 1999, 764–65).

The method of identifying the year most familiar to the modern mind is dating by era; the reckoning of years in sequence from a particular starting point. A number of era systems were used in the middle ages, some of which are still used to this day. One system, counting years *ab urbe condita* ('from the foundation of the city [of Rome]') although actually rarely used in Rome, was nonetheless popularized by the fourth-/fifth-century historian and theologian, Orosius (Blackburn and Holford-Strevens 1999, 676). The Muslim calendar, used in parts of medieval Europe such as Al-Andalus (Spain), dates its (lunar) years from the Hijra (the Prophet's departure from Mecca), while in the Judaeo-Christian world *Anno Mundi* (AM) dating (a measurement of the age of the world) was popularly used in world history chronicles. The precise starting dates of individual systems were frequently disputed, owing to the contradictory claims (and interpretations) of the sources of authority upon which they relied, for example the Hebrew and Vulgate (Latin) Old Testament traditions concerning the age of the world differ considerably from that of the Septuagint (Greek translation of the Old Testament). The form of era dating that eventually won out was *Anno Domini* ('in the year of [Our] Lord'), a system of counting from the year of Jesus' birth. Like other era systems,

the starting date was disputed, not least because the dating criteria offered in the nativity narratives of the canonical Gospels of Luke and Matthew are irreconcilable. Nonetheless, the system of AD dating became dominant, owing to its use by Dionysius Exiguus in his Easter table and its subsequent popularization by Bede in his highly-influential *De temporibus* (703) (Kendall and Wallis, trans., 2010) and *De temporum ratione* (725) (Wallis, trans., 1999).

The historian (both medieval and modern) was frequently required to master a number of these dating methods, as adherence to a single dating system was not mandatory and the employment of multiple dating systems in documents was not uncommon. In annalistic and chronicle texts, patterns of dating criteria are one possible method of identifying periods of chronicling practice and the presence of different textual strands (Mc Carthy 2008; Evans 2010). Medieval Irish annals, for example, generally identified a year by the characteristics of the Kalends (first day) of January, namely the feria (the day of the week upon which it fell) and frequently the luna (day of the lunar month upon which it fell). Thus when the Annals of Inisfallen noted in 990 that *Kł. .iiii. f., i. luna*, it is understood that the Kalends (*Kł.*) (i.e., first) of January was the fourth feria (the fourth day of the week, i.e., Wednesday) and the first day of the lunar cycle (Mac Airt, ed. and trans., 1951, 168–69). In 1317 the same text recorded no less than eleven dating criteria:

> The Kalends of January on Saturday, the fifteenth of the moon; the first year after bissextile, with Dominical Letter B and Tabular Letter A. (postpunctata); the seventh year of the Decemnovennial Cycle, the fourth of the Lunar Cycle, and the last of the Indiction; has five as the Concurrent, and is the tenth year in the Solar Cycle of Dionysius, and the twenty-first of the Solar Cycle according to Gerlandus (Mac Airt, ed. and trans., 1951, 424–25).

Within the subdivisions of the year Roman influence also extended to the names of months and days in various Romance and non-Romance languages (Ó Cróinín 1981) and the method of identifying individual days within the solar months. Days were identified by inclusively counting backwards from three fixed points, the *kalendae* (first), *nonae* (fifth or seventh), and *idus* (thirteenth or fifteenth) of the month, thus the 1st of January is *Kalendis Ianuariis* but the 31st of January is *pridie Kalendas Februarias* (i.e., the day before the kalends of February). Increasing Hellenization in the Byzantine Empire resulted in the abandonment of the Roman backwards dating system, but in the West, outside of Merovingian Francia, forward counting did not make significant progress until the eleventh century (Blackburn and Holford-Strevens 1999, 673).

II Synchronizations: Bringing the Histories of the World into a Single Timeframe

Just as those calculating the dates of religious festivals had to grapple with the complexities of asynchronous calendars, so too anyone wishing to write cross-cultural history (or express the chronological progression of a foreign history using the domestic calendar familiar to their audience) would be faced with similar problems. The most significant figure to rise to the challenge was the late-third-/early-fourth-century bishop of Caesarea, Eusebius. His works became popular in the West through the Latin translations of Jerome and were frequently drawn upon for the preambles of medieval chronicles (Burrow 2007, 189), for example in Otto of Freising's *Chronica sive Historia de duabus civitatibus* (Mierow, trans., 1966).

Eusebius set himself the monumental task of writing the first-ever world history, in which he synchronized the regnal years of the nineteen most important world kingdoms in vertical columns and noted important events under their appropriate year. Eusebius, however, actually used three chronological systems: years elapsed since the birth of Abraham, the Olympiads, and regnal years of the aforementioned kings, pharaohs, emperors, etc. In constructing his chronology Eusebius, of course, faced many of the challenges outlined above (section C.I). The nineteen kingdoms operated a variety of lunar, solar, and lunisolar calendars, which never synchronized with each other. Similarly, reign lengths posed problems; some kingdoms used the anniversary principle, while others synchronized the second regnal year with the beginning of the following year according to the local calendar in use and each subsequent calendar year was equated with a regnal year (Burgess 1999, 28). In order to bypass this calculatory quagmire, Eusebius coordinated all the regnal years with the calendar used in his own Caesarea. Thus the 'regnal years' he records were not the actual regnal years of each ruler but rather "useful chronological place-holders for calendar years" (Burgess 1999, 30). The ultimate aim of Eusebius's highly providentialist Chronicle was not to provide a rigorous chronological apparatus; rather it was intended to prove the superiority of the Hebrew religion (and more to the point its Christian successor), through making manifest its antiquity (Burrow 2007, 189–90).

Similar motives inspired peoples on the fringes and adjoining the former Roman Empire, who were nonetheless heavily influenced by Roman Christianity. For example, the Irish (who had never been part of the Empire) faced the vexing problem of chronologically arranging their history (and pseudohistory) so that it synchronized with the histories of the peoples of the rest of the known world, which they encountered through Greco-Roman and early Christian sources. As a

people converted to Christianity and convinced of the veracity of biblical history, the Irish were faced with the challenge of finding for themselves a place within historical traditions that did not explicitly include them. Irish authors produced a substantial body of pseudohistory that helped forge Irish identity, which had, as points of chronological reference, events in Biblical and Classical history. Indeed, they also borrowed from the substance of these works. Thus the origin legends of the Irish (such as *Lebor Gabála Érenn* ['The Book of the Conquest of Ireland'] which purport to tell of the wanderings of the ancestors of the Irish) (Macalister, ed. and trans., 1938–1956) drew upon Orosius's *Historiae adversum paganos* (Deferrari, trans., 1964) and were ultimately temporally anchored in a chronological model based upon Eusebius-Jerome (Jaski 2009, 68). The pervasive influence of Eusebian-style chronological tables may be seen in the recording of Irish history of the Christian era, for example in the parallel lists of kings and archbishops found in Bodleian Library MS Laud 610 (Meyer, ed., 1913, 478–79).

The Irish were not alone in using the traditions of the Biblical and Classical world as a means of anchoring their origins within a universal chronology. According to the so-called seventh-century *Chronicles of Fredegarius* the Franks were descended from exiles of Troy (Krusch, ed., 1888, 45–47; 93). Likewise the *Historia Brittonum*, which was probably written in Wales ca. 830, claimed that the Britons were descended from Brutus/Britto, a wandering great-grandson of the Trojan hero Aeneas. (Morris, ed. and trans., 1980, 18–20; 59–61). As late as the twelfth century the great Icelandic historian Ari inn fróði Þorgilsson (Ari the Knowledgeable) combined AD dating with the terms-in-office of Icelandic lawspeakers in his magnum opus, *Íslendingabók* (Grønlie, trans., 2006), in order to integrate the history of recently settled (and even more recently Christianized) Iceland into world history (Würth 2004, 158).

III Calculating the End of Time

The Book of Revelation posited an inherent problem for Christianity. On the one hand, it posited a future free of injustice and social ills. On the other hand, those protesting the order of the world, or merely seized by religius furor, might make religious claims of an impending judgment day and the thousand-year "kingdom of the saints." The term "millennialism" itself shows the significance given to the thousand years spoken of in Revelation 20; we find the term, for instance in Radolfus Glaber's chronicle written ca. 1000 and "the half-time after the time" in Botticelli's *Mystical Nativity*. Such claims occur throughout the medieval period, though some of the most well-known, such as the 1534–1535 Münster rebellion, date from the Reformation.

The fact that various medieval intellectuals made attempts at calculating the age of the world has important millennial implications. The purpose of the exercise of determining the age of the world was to fix the ending point, since the history of the world was generally held, followng Sextus Julius Africanus, to be organized into a Great Week: 6,000 years of historical time, and then, following the plan of Revelation, a thousand-year sabbatical kingdom of God on earth. The general trend in this calculus was that the more the writer had invested in this world, the further off the Apocalypse. This presents us with a moving date given by successive generations of authorities, who placed it more or less distant according to their proclivities. Thus, Hippolytus expected it in 500, Augustine, Jerome, and Gregory of Tours (who had to argue against the "false Christ of Bruges") around 800, Bede around 1000. On the other hand, Joachim of Fiore (1135–1202) predicted it sometime in the thirteenth century. Later followers of Joachim such as Arnold of Vilanova also predicted immanent apocalyptic dates. Needless to say, the Church tended to frown upon such heterodox beliefs for their inherent destabilizing nature (Cohn 1990).

D The Social Use of Time

I Life Rhythms

Although many computistical pursuits were only performed by an educated minority of the population, ordinary medieval people would probably have been reasonably aware of the necessity of recording the passage of time for a variety of reasons, not least because their agrarian-based survival depended upon it. Even though different numbers and starting dates of seasons were recognized by various communities, the changes in weather that generally accompanied the lengthening and shortening of daylight were vital for all facets of agricultural life. Ploughing, sowing, harvesting, insemination, and slaughter were all determined with reference to both the solar calendar and the realities of climatic conditions. In addition, these activities were punctuated (and partially defined) by various festivals, many of which were probably intended to avert possible dangers as much as to celebrate past and present good fortune (Kelly 2000, 460–61). Many of these agricultural festivals were held during the summer and autumn months, which helped balance out the distribution of festivals in the social calendar, as most of the main Church festivals took place in Winter and Spring (e.g., Christmas and Easter) (Blackburn and Holford-Strevens 1999, 651).

Just as festivals may be understood as attempts to ward off potential misfortune, particular importance was also attached to the designation of

certain days as auspicious or inauspicious for certain activities. For example, the so-called "Egyptian Days" (of which it was believed that there were two in each month) were held to be particularly unlucky and it was considered unwise to engage in a variety of activities on such days—e.g., entering into contractual arrangements or starting journeys. The Roman Republic had occasionally sacrificed the smooth running of their calendar to the demands of superstitions or political pragmatism but the Christian requirement for fixing the date of Easter precluded such expediencies. The consequences of inappropriate activity on inauspicious days could be visited upon an individual or the community. A patient might be unnecessarily endangered by undergoing phlebotomy on an Egyptian Day, but when Richard I of England was crowned on one (3rd September 1189), the chronicler William of Newburgh noted in his *Historia rerum Anglicarum* that it proved extremely unlucky for the Jews of London, who were subject to a pogrom by their fellow townsmen. To William they appeared to have metaphorically gone from one Egypt to another (Howlett, ed., 1884–1889, I, 294). In addition to individual days, temporal boundaries (such as twilight or the beginning of winter) were also fraught with supernatural danger, especially when experienced at physical boundaries, where the convergence of multiple forms of liminality added to their potency (Mac Cana 1983, 127).

Socially, linear and cyclical views of time were vital to the rhythms of life and medieval people would have been conscious of a "plurality of 'times'" (Porter 2010, 1351). Seasons and tides followed expected cycles on a linear trajectory, while the life of individual beings too would follow a cycle, for example the progression from childhood (Classen, ed., 2005) to old age (Classen, ed., 2007), although this latter cycle was non-renewable. The juxtaposition of cyclical and linear time is brilliantly expressed in the Irish poem *Aithbe damsa bés mara* ("Ebb-tide has come to me as to the sea," popularly known as "The Lament of the Old Woman of Beare") (Ó hAodha, ed. and trans., 1989), in which an old woman staring at the sea recalls her youth among the kings of Cashel in the inland plain of Femen. In the words of John Carey:

> The 'Lament' makes extensive use of two natural images: the sea along the rocky coast of the Beare peninsula, and the rich plain of Femen in Tipperary. In terms of the *argument* of the poem, each has the same import, exemplifying the cyclical regeneration of nature in contrast with the linear existence of the human individual: the tide will return after every ebb, and grass sprouts again every year, but the Old Woman's youth and beauty are gone forever. In terms of the poem's *narrative background*, however, sea and land may be seen as reflecting another contrast: in age the speaker is associated with the bleak coast (as the very name 'Old Woman of Beare' and the associated local legends indicate); while her youth as consort of kings was evidently spent in the rich plain, with its chariots and royal strongholds. On different levels, then, the poem presents two distinct temporal oppositions:

> cyclical versus linear time (plain and sea versus woman), and past versus present (plain and youth versus sea and age) (Carey 1999, 31).

Just as the Old Woman of Beare foresaw an end to her own enjoyment of linear and cyclical time, so a variety of belief systems proposed that these cycles would ultimately come to a head in an unknown (but frequently considered imminent) point in the future, such as the Christian Apocalypse or Norse *Ragnarok*.

II Legal Usage

For legal purposes, time did not need to be calculated using years or even their subdivisions, but could rather be measured in the more variable unit of the generation. This was particularly true when dealing with matters of inheritance, especially within kin groups. Not only was membership of a kin group defined through counting the ascent or descent of generations from a central figure, but the period required for certain inheritance processes to be completed might be measured in generations, rather than in years. Thus, just as the twelfth-/thirteenth-century Welsh lawbook *Llyfr Cyfnerth* notes that kin land is only shared out within a four-generation group, it also states that the children of a Welshwoman given in marriage to a foreigner do not come into possession of their share of her paternal homestead until the third generation (Charles-Edwards 1993, 211–15).

Closely allied to the role of generation counting in inheritance was its function in regulating systems of social mobility (Jaski 2000, 171–72). In seventh- and eighth-century Ireland, the highest grade of commoner could rise to the rank of the lowest grade of noble, provided the property qualifications for nobility could be maintained over three generations (Kelly 1988, 11–12). The man of the third generation was known as a *fer fothlai* ("man of withdrawal"), as he was in the process of withdrawing from the ranks of the commoners and ascending toward lordship. His son would, in turn, become a fully-fledged lord (Binchy, ed., 1941, 10). Similarly, in Burgundy from 1275, a three-generation holding of a purchased fief conferred nobility, a process which would otherwise take forty years in Normandy or one hundred years in Brittany (Bush 1988, 74). Downward social mobility, however, was probably more common and it too was sometimes measured in generations. The polar opposite of the early Irish *fer fothlai*, was the *fuidir* (semi-freeman), whose descendants would become *senchléithe* (serfs bound to the land who were transferable with its ownership), should they fail to improve their status over three generations (Binchy 1984, 10–11).

The calculation of Easter discussed above (section B. III) also determined the dates of many of the other feasts and rituals of the Church, such as Shrovetide,

Ascension Day, and Whitsunday/Pentecost and a great deal of non-ecclesiastical business was organized and conducted with reference to these days or days determined in relation to them (in addition to fixed feasts, like Christmas). This included court ceremonies held at major feasts such as Easter and Pentecost or the falling due of rents and customs on particular days. For example, in England (from at least the early thirteenth century), the second Monday and Tuesday after Easter were known as Hockdays and were the chief payment days in spring (Blackburn and Holford-Strevens 1999, 627). Their corresponding payment day in autumn was Michaelmas (29th September), which was fixed within the solar calendar. The payment of Church dues by specific dates was frequently regulated in law but other legal processes might also be enjoined or forbidden at certain periods. Thus the 1008 law code of the Anglo-Saxon king Ethelred the Unready legislated that "ordeals and oaths are forbidden on feast-days and the legal Ember days, and from the Advent of the Lord until the octave of Epiphany, and from Septuagesima until 15 days after Easter," while secular debts were also to be paid before or after these seasons (Whitelock, trans., 1955, 407).

III Urban and Rural Work Hours

For purposes of everyday economic production, time regulation had to deal with much shorter periods. Chief amongst these were work hours. As Gerhard Dohrn-van Rossum summarizes, "In the cities, working time was determined in part by daylight, in part by the ringing of the Hours in various churches, in part by civic time signals" (Dohrn-van Rossum 1996, 293). In Paris, for instance, the transition from night to day was determined by such experiential values as being able to recognize a man in the street or distinguish between two coins, while civic symbols were epitomized by the curfew bell and the dinner bell (Gauvard 1991, 480–81). Claude Gauvard, in her *De Grace Especial*, made a comprehensive study of the use of hours in descriptions of crimes found in late fourteenth- and fifteenth-century letters of remission—some 3,752 from the reign of Charles VI (1380–1424) alone (Gauvard 1991, 491). In some 35% of Gauvard's cases, the hour is specified. Gauvard divides the expression of time into several categories: clock-time (*horlogére*), used in 14.5% of cases where the hour was specified; ecclesiastical hours (*ecclésiastique*), 11.5%; "folkloric" (*folklorique*, customary expressions such as *entre chien et loup*), 4.0%; "alimentary" (*alimentaire*, such as around lunchtime), 27.5%; "solar" (*solaire*, such as "sunrise and sunset"), 29.0%. Besides these, 13.5% have "many qualifiers" (*plusiers qualificatifs*) or "others" (*autres*). Use of time was not what one would expect between classes: Gauvard notes that clerics were less likely to use clock-time (1.1%) than guild-members (7%), officers

(4.5%), or even laborers (3%), but more likely than men-at-arms (0%); clercs were more likely, however, to use ecclesiastical time or folkloric time (16.3% each, as compared to 8.5%/0% for officers, 0% in each for men-at-arms, 4.5%/1.0% for guild-members, and 4.0%/2.0% for laborers).

The canonical hours were initially eight, corresponding to the sequence of the Passion and the words of Psalm 119 ("seven times a day I praise you"): Matins (sunrise), Sext (midday), Compline (sunset), and Laudes (around midnight), to which were added the quarter-hours mentioned in the Bible, whose timing depended on the natural signals: Prime (shortly after Matins, around 06:00); Tierce (around 09:00), None (originally 15:00, but gradually moved closer to modern noon, to which it gives its name, over the course of the thirteenth century), and Vespers (18:00 more or less—later in summer, earlier in winter). Later, sext disappeared and nones moved to midday; the reasons for this are obscure. Dohrn-van Rossum points out that the idea of the modern regime of twenty-four equal hours—the "four o'clock" of Chaucer's Parson's Prologue—gained currency through the fourteenth century as the municipal mechanical clock became more widespread. Nonetheless, this was not an overnight transformation: according to Claude Gauvard, it was 5% under Charles VI, but 11% under Louis XI (r. 1461–1483). Gauvard also notes that measures of duration such as the half-hour, quarter-hour, and half-quarter hour gained currency. However, the older ways of reckoning time clearly still persisted, and clocks, such as the fifteenth-century example on the choir screen of Chartres cathedral, usually showed both equal and unequal hours. Moreover, the system of "Italian hours," which were kept in Italy and some parts of Bohemia and even Poland and reckoned the day in twenty-four hours that began at sunset (as opposed to the "French hours" that began and ended at midnight) lasted until the mid-eighteenth century and beyond in certain places.

One of the first guilds to have their labor organized by equal hours was the Parsian *métier* of the *tondeurs de draps*, or cloth-cutters. In 1384, we find that from the Feast of St. Remigius to Candlemas (February 2), they were required to go to work at 12 o'clock at night and work until daylight, whereupon they had a break until 9 o'clock. There was a further one-hour break at one PM, and then they worked to sundown. The rest of the year, they worked from sunrise to 9 o'clock in the morning, then had a one-hour break, and then worked to one o'clock in the afternoon, when they had either a one- or two-hour break, depending on the time of year. They were then required to return to work until sunset, at which time they had a half-hour to drink and refresh themselves at their work site. They were further enjoined not to quarrel about the work-times and not need to be reminded of them daily. However, it is important to remember that these regulations existed alongside other, more traditional measures of time.

Hourly wages would have also simply been impractical in many situations. The cloth-cutters of Paris were clearly an exception in that they worked in a centralized factory system; most of the work in urban industries was accomplished through a putting-out system. And, as E. P. Thompson and other economic historians have observed, labor in the premodern period was hardly performed at a uniform rate, with workers observing a "Saint Monday" of slow production at the start of the week, and speeding up toward the end in order to earn enough for their needs and pleasures (Thompson 1967, 76). That this was true also in thirteenth-century Genoa is suggested by Epstein's study of notarial casebooks, in which he notes a preponderance of business on Tuesdays and suggests that "E. P. Thompson's 'Saint Monday' may be a custom as old as the work week" (Epstein 1988, 250–51).

Wages and work hours in the post-Plague rural economy were often a source of conflict, and in turn gives us insight into timekeeping in the rural economy. Dohrn-van Rossum cites the well-known case of the vineyard workers of Sens and Auxerre in Burgundy to argue that church bells were becoming insufficient for measuring working time in the late fourteenth century. This was actually a series of ongoing conflicts, beginning in 1383, when the nobility, clergy, and bourgeois of Sens complained that the workers were demanding high wages and leaving the vineyards after only a half day's work—"between midday and None, in any case long before sundown," as Dohrn-van Rossum summarizes (Dohrn-van Rossum 1996, 294).

A royal ordinance established a maximum wage and that they should work from sunup to sundown; an appeal to the Parlement of Paris was rejected. In 1392, suffering from war-related devastation to their businesses, the vintners of Auxerre obtained a similar order. This time, the workers' protests led to widespread disturbance; they claimed that the half-day was traditional, that None had crept closer to the third or fourth hour of the afternoon—a timing for None that Dohrn-van Rossum notes was, in fact, more common to the thirteenth century, even if the workers employed the new-fangled clock-time to express their objections (Dohrn-van Rossum 1996, 294–96). Moreover, as we can see from the drafts of the acts, neither side could agree when work ceased—the "cliquest" (that is, the *clicket* or pre-ringing bell) to None, two o'clock, two-thirty, or three o'clock. In the end, the king tied the end of the day's work to sundown; it was not until 1447 that the Parlement of Paris definitely tied them to clock-time and decreed work would end at the last stroke of the seven o'clock ringing.

Running medieval universities likewise required a great deal of coordination for scheduling and duration of faculty meetings, examinations, and the length of lectures. By the very nature of their daily routines, the members of the University tended to be conscious of time, and perhaps at an earlier date, than other

segments of society. We often find temporal notes appended to decrees as a usual part of the opening formula, to inform the reader that a decision had been reached in a lawful and customary assembly. Likewise, universities are some of the earliest institutions to make use of clock time. This academic concern for the equal hour is reflected not only in the legal decrees issued by the faculty, but also the Scholastic and theological concerns discussed above.

E The Development of Clock Time

Time, as we have seen, is no less a social concept than a scientific one. These two ideas have become inextricably intertwined in Western histories of chronography, with a primary assumption being that the revolution of the hour-hand around the clock-face was a necessary antecedent to the revolution in production. As Lewis Mumford wrote, "The clock ... is a piece of power machinery whose 'product' is seconds and minutes: by its essential nature it dissociated time from human events and helped created the belief in an independent world of mathematically measurable sequences: the special world of science" (Mumford 1934, 15). The central historiographical debate, then, centers on when the equal hours began to be kept, as opposed to mere prayer-times.

The first observation that even a casual student of the history of time might make is that timekeeping and astronomy were inextricably intertwined. The Benedictine Rule, following earlier writers such as Cassian and in keeping with Psalm 119: 62 of the Vulgate (*medio noctis surgam ad confitendum tibi super iudicia iustificationis tuae*, "at midnight I rise to give thee thanks because of your righteous judgements") and 119: 164 (*septies in die laudavi te super iudiciis iustitiae tuae*, "seven times a day I praise thee for your righteous judgements"), established the eight times-daily round of prayer. Times for work and prayer were specified, as well—in chapter XLVII of the Rule, the office of None is at the "middle of the eighth hour" from Easter to October, and from October to Lent, Tierce is at the "second hour." These were not fixed times in the modern sense, but unequal hours that varied by the length of season, signalled by bells that were in turn regulated by water clocks which essentially functioned as timing devices. The whole system was maintained by astronomical tables and verified by observation. Monastic life was thus tied not only to the cycle of the seasons, but also the stars.

More than knowing when to rise for prayer, because of the timing of Easter a good cleric had to be able to determine the equinoxes. Indeed, the first post-classical documentation of a water clock was for this purpose. Bede, in *De Temporum Ratione*, discusses the use of what is presumably such a device

(*horologica*) to help find the vernal equinox. Similarly, in his *Historiam ecclesiasticam gentis Anglorum*, he quotes a letter from the abbot Ceolfrid to the same effect. Astronomy *was* chronometry, and chronometry was astronomy. Macrobius (fl. 395–423), whose writings were known to Bede, also mentions using a clepsydra for astronomical observations in Book 21 of his *Commentariorum in Somnium Scipionis*.

However, gleaning information from the motion of the sky, or modeling it, wasn't simply religious duty or abstract knowledge: it was a glimpse of the sublime. The preeminent medieval text on cosmology was Cicero's *Somnium Scipionis*, the passage from his *De Re Publica* in which the Roman general and Stoic hero Scipio Aemilianus is raptured into the heavens to observe both the sublime motion of the heavenly spheres and hear their subtle music while at the same time realizing the infinite smallness of all human activities. The easily-Christianized moral message follows that while the sublunar world is to held in contempt, the virtuous have their reward in heaven. This passage was well-known to Bede, Abelard, and other medieval intellectuals from Macrobius's commentary, which was not only a *summa* of ancient astronomy, but a primer of neo-platonic philosophy: Macrobius's spheres are not only natural phenomena, but also manifestations of divine will. Humans, created in God's image, can, if virtuous, take their place amongst the stars whose regular movements astronomers can track with their devices. It follows that regular motion, timekeeping, and godliness go hand-in-hand. For instance, Isidore of Seville's fifth book of the *Etymologiae* was on "laws and time"; the two subjects are the regulators of the world.

The wise use of time was also a trope of virtue. Candles were of religious, symbolic, and practical importance, and marking time by the burning of candles is a trope that occurs often in the lives of saintly kings. Asser, in his *vita* of Alfred the Great, has the king having six candles, each of twelve pence weight, burned every day in a specially-constructed horn lantern (Keynes and Lapidge, trans., 1983, 107–08). Each candle, in turn, was marked in twelve divisions, each of which would lasted twenty minutes. If true, the expense would have been exorbitant. Guillaume de Saint-Pathus's *vita* of St. Louis gives great detail on his devotion and his singing the canonical hours with his chaplains, as well as the candle trope. This trope of candle-burning may explain why, even though Charles V ordered public clocks to be built in Paris, he himself made use of portable clocks and hourglasses (Dohrn-van Rossum 1996, 120). Christine de Pisan, in her biography of the king, notes that he burned candles to divide the day into three parts (Solente, ed., 1936–1940, 56).

In his seminal 1960 *Annales* essay "Merchant's Time and Church's Time," Jacques Le Goff argued that the critical leap in time-measurement, the ordaining of regular hours, came about as part of late medieval urbanization and the desire

for ordering time (Le Goff 1982, 29–42). Le Goff challenged the wisdom of the previous generation of French medievalists, particularly Marc Bloch's conception of a vague medieval "perpetual floating of time" (*perpetuel flotment du temps)* and Lucien Febvre's dichotomy between premodern experiential "lived time" (*temps vecù)* and modern "measured time" (*temps-mesurè*) (Bloch 1939, 1.117; Febvre 1942, 426–34). Le Goff posited, instead, two competing systems: a particularly Christian ontology of time as having a beginning and an end—bookended, as it were, between Genesis and Revelations, and the commercialized time of the emerging merchant class of the thirteenth and fourteenth centuries. "The communal clock," Le Goff further tells us, "was an instrument of economic, social, and political domination wielded by the merchants who ran the commune." This time was rationalized as church time could not be, thus linking modern time regimes and capitalism.

This thread was picked up by Gerhard Dohrn-van Rossum in his magisterial 1992 work *Die Geschichte der Stunde* (Dohrn-van Rossum 1996). Dohrn-van Rossum exhaustively traces the rise of the mechanical clock in thirteenth- and fourteenth-century Europe, attributing the mentality of keeping regular hours to the fourteenth-century technological innovation of public clocks, arguing that within the space of a mere two generations the pace of urban life that would hold until the late eighteenth century had been set. This development, in turn, often came from an unexpected quarter, spurred on by the desire of monarchs and princes to compete for prestige—often over the protests of merchants who saw such extravagances as unnecessary, thus replacing Le Goff's Marxist idea of the development of timekeeping regimes with a more Whiggish one.

F Development of the Mechanical Clock

The regularity of monastic prayer is why Lewis Mumford saw the monastery as the engine that produced the machine that produced time. Dohrn-van Rossum notes that by the year 1000, monastic water clocks were usually made to sound bells or another alarm, thus functioning as a sort of timing device (Dohrn-van Rossum 1996, 60–64). To give a simple example, in the device for keeping the unequal hours discussed by Vitruvius in Book IX of *De Architectura* a float placed on top of the water basin regulates the descent of a weight, which in turn drives a mechanical device such as a clock-face or bells. The primary observational device for taking the time from the sun and stars so as to calibrate the water clock would have been the astrolabe, which was introduced from the Muslim world in about the eleventh century and, as Emmanuel Poulle has shown, was also used to reckon the equal hours from the mid-thirteenth century on (Poulle 1999, 140).

Indeed, the influence of Arabic science on Western timekeeping cannot be underestimated: As David King has stated, "virtually all innovations in instrumentation in Europe up to ca. 1550 were either directly or indirectly Islamic in origin or had been conceived previously by some Muslim astronomer somewhere" (King 2004, vol. 2, ix). The Muslim world was not only as tied to regular daily prayer as Latin Christianity (if not more so) and made use of shadow-angles and astrolabes to determine the proper times, but was, to a much greater extent than the West, the inheritors of Greek science (Saliba 1995; King 2004). Scholars in ninth-century Baghdad were capable of creating fairly complex water clocks (Hill, trans., 1979; 1981), and German chronicles speak of an immense mechanical astronomical simulation given to Frederick II in 1232 by Sultan al-Ashraf of Damascus (Dohrn-van Rossum 1996, 73–74).

By the mid-thirteenth century, European water clocks had not only become quite complex, but attempts were possibly being made to keep track of twenty-four hour time (presumably, of equal hours). For instance, in his *De Anima*, written about 1240, Guillaume of Auvergne describes astronomers' use of water clocks that moved "by water and weights," though he notes that these are inaccurate. Still, just like the perpetual-motion machine that appeared in contemporary treatises, the *idea* of a reliable clock by which one can know the motion of the heavens to tell time in an objective sense and, presumably, thus synchronize the functioning of human society, was clearly present by the late thirteenth century. For instance, Robertus Anglicus, a professor at Montpellier, noted in his 1271 commentary on Johannes de Sacrobosco's ca. 1230 *Treatise on the Sphere* that a good, accurate clock would keep time with the heavens (Thorndike 1949, 229–30).

The era of the water clock ended in about 1300 or shortly thereafter. Its replacement was a mechanism that became standard until the late seventeenth century: The virge-and-foliot escapement. The "virge" part of the verge and foliot is named from the Latin *virga*, "stick" or "rod." The escapement itself, or "crown wheel," is a gear with vertical sawtooth-shaped teeth (thus the name "crown"). The virge has two tabs called "pallets" offset at such an angle that, as the crown wheel rotates thanks to the downward pull of the weights, the pallets will engage and rotate the virge, which in turn moves the weighted "foliot," a weighted bar. A tooth on the opposite side then catches the other palette, rotating it back and returning the foliot to its original position. The verge-and-foliot serves to transform the downward pull of gravity into a regular oscillating motion, producing the characteristic "tick tock" as it rotates forward and back. Moreover, if the weights on the foliot are moved inwards or outwards, the period of the cycle can be adjusted, thus regulating the clock.

An interesting precedent was the strobe clock, such as the one constructed by Richard Wallingford, twenty-eighth abbot of St. Albans. In his brief tenure

between 1327 and his death of leprosy in 1335, he not only renovated the abbey and restored its privileges, as well as composed works on mathematics, but also designed (but did not complete) a remarkable clock. John D. North of the University of Groningen, who has made the definitive study of Richard of Wallingford his life's work, has painstakingly reconstructed a hypothetical model of this clock (North 2004).

Much as hour-candles became tropes of virtue, so, too did other timekeeping devices. A psalter from the beginning of the twelfth century (Paris, Bibliothèque de l'Arsenal, 1186) attributed to Blanche of Castile shows on the verso side of its first folio a miniature of an astronomer taking measurements of the stars with an astrolabe while one assistant reads from a book in Latin and the other writes in a Latin manuscript—an appropriate subject for a psalter, considering that prayer times were set by observation. Dante, in his *Paradiso* canto 10, lines 139–48 considers the heavens as the clock that calls one to matins, and in 24:13–15 he sees Beatrice dancing with the other blessed like the gears of a clock. Heinrich Suso, the mystic of the Rhineland school, gave his Latin translation of his *Das Büchlein der ewigen Weisheit* ("Little Book of Eternal Wisdom," written between 1327 and 1334) the title of *Horologium Sapientie*. A generation later, the chronicler Jean Froissart, in *L'Horloge amoureuse* (ca. 1369), made the parts of the escapement clock into a neo-Platonic allegory of love—incidentally giving us an excellent description of the inner workings of a fourteenth-century clock.

G Conclusion

Medieval ideas of time are fascinating both for their similarity to our own and their inherent alterity. Though the need to order human society was no less than today, the worldview, and available means to measure time, were quite different. Since the premodern era was, in the words of Barbara Tuchman, a "world lit only by fire," the length of daylight was the quotidian measure of time; since it was an agrarian society, the cycle of the year and growing season were also a primary indicator; since it was a Christian world, the liturgical cycle provided order to the year. In the longer term, subjective natural cycles such as generations were made the basis for law and custom. On top of this were conceptions derived from antiquity, such as the Indiction, and Christian natural history, such as Creation and Judgment. While many of these, such as the calendar, are still used today, we tend to be more removed from natural cycles, particularly those of light and darkness.

Medieval thought was nonetheless the foundation of our own Enlightenment ideas of time. Not only was the Scientific Revolution founded on medieval

astronomy, but it was in the Middle Ages that the mechanical clock, the physical embodiment of the measurable and absolute hour, was developed. This, in turn, opened the possibilities of abstract measurement of phenomena that led, ultimately, to the modern scientific conception of the world. In this way, far from being a peripheral subject, ideas of time and timekeeping, whether Christian or Enlightenment, can be said to be the basis for world-systems.

Select Bibliography

Blackburn, Bonnie and Leofranc Holford-Strevens, *The Oxford Companion to the Year* (Oxford 1999).

Burrow, John A., *A History of Histories: Epics, Chronicles, Romances and Inquiries from Herodotus and Thucydides to the Twentieth Century* (London 2007).

Dohrn-van Rossum, Gerhard, *History of the Hour: Clocks and Modern Temporal Orders*, trans. Thomas Dunlap (1992; Chicago 1996).

Dohrn-van Rossum, Gerhard, *Die Geschichte der Stunde: Uhren und moderne Zeitordnungen* (Munich 1995).

Le Goff, Jacques, "Merchant's Time and Church's Time," *Time, Work, and Culture in the Middle Ages*, trans. by Arthur Goldhammer (Chicago 1982), 29–42.

Mumford, Lewis, *Technics and Civilization* (New York 1934).

Murdoch, John, "From Social into Intellectual Factors: An Aspect of the Unitary Character of Late Medieval Learning," *The Cultural Context of Medieval Learning*, ed. John Murdoch and Edith Sylla (Boston, MA, 1975), 271–339.

Porter, Camarin M., "Time Measurement and Chronology in Medieval Studies," *Handbook of Medieval Studies: Terms – Methods – Trends*, ed. Albrecht Classen (Berlin and New York 2010), vol. 2, 1350–68.