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Historians have long recognized that the rebirth of science in twelfth-century Europe flowed from a search for ancient scientific texts. But this search presupposes knowledge and interest; we seek only what we know to be valuable. The emergence of scholarly interest after centuries of apparent stagnation seems paradoxical.

This book resolves that seeming contradiction by describing four active traditions of early medieval astronomy: one divided the year by observing the Sun; another computed the date of Easter Full Moon; the third determined the time for monastic prayers by watching the course of the stars; and the fourth, the classical tradition of geometrical astronomy, provided a framework for the cosmos.

Most of these astronomies were practical; they sustained the communities in which they flourished and reflected and reinforced the values of those communities. These astronomical traditions motivated the search for ancient learning that led to the Scientific Renaissance of the twelfth century.

ASTRONOMIES AND CULTURES IN EARLY MEDIEVAL EUROPE

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Abbreviations

AASS	*Acta Sanctorum* (Paris)
BGPMA	*Beiträge zur Geschichte der Philosophie des Mittelalters* (Münster i. W.)
BL	British Library
BN	Bibliothèque Nationale
BOT	*Bedae opera de temporibus*, (Cambridge, Mass., 1943)
CCCM	*Corpus Christianorum, Continuatio Medievalis* (Turnholt)
CCM	*Corpus Consuetudinum Monasticarum* (Sieburg)
CCSL	*Corpus Christianorum, Series Latina* (Turnholt)
CIL	*Corpus Inscriptionum Latinarum* (Berlin)
CIMRM	*Corpus Inscriptionum et Monumentorum Religionis Mithriacae* (The Hague, 1956)
CLM	Codex Latinus Monacensis
CSEL	*Corpus Scriptorum Ecclesiasticorum Latinorum* (Vienna, Prague, and Leipzig)
DSB	*Dictionary of Scientific Biography* (New York)
EETS	Early English Text Society Publications (London)
HAMA	Otto Neugebauer, *A History of Ancient Mathematical Astronomy* (Berlin, Heidelberg, and New York, 1975)
HMML	Hill Monastic Manuscript Library
Loeb	Loeb Classical Library (London and Cambridge, Mass.)
MGH	*Monumenta Germaniae Historica* (Berlin, Hannover, and Leipzig). The parts of this series have been abbreviated as follows:

Auct. Antiq.	*Auctores Antiquissimi*
Cap.	*Capitularia*
Conc.	*Concilia*
Epp.	*Epistolae*
Leges.	*Leges nationum Germanicarum*
Poet.	*Poetae latini Aevii Carolini*
Scr. Rer. Merov.	*Scriptores rerum merovingicarum*
SS	*Scriptores*

PG	*Patrologia Graeca* (Paris)
PL	*Patrologia Latina* (Paris)
RIG	Recueil des Inscriptions Gauloises (Paris)

Preface

> The real measure of Christian religious culture on a broad scale must be the degree to which time, space, and ritual observances came to be defined and grasped essentially in terms of the Christian liturgical year.
>
> John van Engen[1]

Early medieval science presents an irritating historical paradox. The conventional view of science in the Hellenistic and Roman periods portrays a declining tradition typified by superficial handbooks and encyclopedias. Conversely, the reemergence of science in Western Europe began with the active search by medieval scholars for Arab astronomy as early as the tenth century. Yet such active inquiry presupposes knowledge and interest; we seek out only what we already know to be of value. This emergence of scholarly interest after centuries of apparent stagnation defines the paradox.

This book attempts to explain that seeming contradiction by examining early medieval knowledge and practices, attitudes, and institutions reflecting on the heavens. In my discussion of medieval astronomies I have abandoned two common assumptions about astronomy. The first is that of taking the rapid change of modern science as normal and measuring other sciences against some standard of progress. For progress is only half of the picture of science; its goal is not just to expand the realm of the known, but to preserve what is known against error. This is especially true in the natural knowledge of traditional cultures,[2] but even modern scientists, firmly devoted to the advancement of knowledge, spend much of their time passing on what they know to their students.

Thus when we look at the early Middle Ages, we should not consider that the only alternatives were progress or stagnation; rather, they were progress, preservation, or decline. Our question then is not what contributed to progress in astronomy, for episodes of progress were few.[3] Instead, we will ask what forestalled the decline of astronomy and shaped the continuation and renewal of astronomical practice and knowledge from the fourth to the thirteenth centuries.

1. Van Engen, "Christian Middle Ages," p. 543.
2. See, for example, the essays in Wilson, *Rationality*; Horton and Finnegan, *Modes of Thought*; and Hollis and Lukes, *Rationality and Relativism*.
3. Progress was not as rare as suggested by the stereotype of the "Dark Ages" or by one writer who summarized the achievements of medieval astronomers in a chapter consisting of four blank pages. Henry Smith Williams, *The Great Astronomers* (New York: Simon & Schuster, 1930), pp. 99–102. I owe this reference to Owen Gingerich.

We already have the skeleton of an answer, known to anyone who has ever surveyed medieval history. The Christian church, we are told, and particularly the monasteries, preserved classical learning. But can we be more precise: can we determine what kinds of astronomies survived through the early Middle Ages? Can we find what practical or social or ideological functions these astronomies had that made them useful to influential groups in early medieval society and therefore worth preserving? Finally, can we find how these astronomies influenced the search for ancient learning? To what extent can we put meat on these bare bones to see the full countenance of early medieval astronomy?

In seeking to flesh out the skeleton of early medieval astronomy we are forced to challenge the second common assumption: that astronomy can be treated as a single discipline whose practitioners share the same concerns, raise the same questions, and employ the same methods. Rather than limit ourselves to the kind of astronomy that has left its mark on modern practice, I prefer to consider as astronomy any attempt by the members of a community to establish a framework that makes their observations of the heavens intelligible. Since the principal restriction that this definition proposes is that astronomy must be tied, at some point, to observations of the heavens, it leaves room for a wide range of astronomies.

Thus we must begin by distinguishing among medieval astronomical traditions, identifying the problems they dealt with and the astronomical techniques they employed. There are many differences that can help us distinguish different kinds of astronomies, but for the early Middle Ages a few seem most significant. Is the astronomy based purely on observation, or does it use mathematical techniques to predict future observable phenomena? If it does use calculations are they based on geometrical and trigonometric models or on simple arithmetic? Does it trace the continuous motion of bodies, or does it determine the times or places at which individual celestial events occur? If it is concerned with events do these recur once a year or month, and so define a calendar, or every day so as to mark particular times in a day? Which celestial bodies does the astronomy consider: the stars, Sun, Moon, or other planets?[4] Applying these criteria to the early Middle Ages, we can distinguish at least four distinct astronomical traditions.

The first kind of astronomy we encounter is an ancient tradition of dividing the year into eight equal parts using simple observations of the rising and setting Sun. The central concern of this astronomy was to determine ritually and calendrically important dates, but the method was strictly observational. Observers noted when the Sun arrived at a particular point as a way to mark the arrival of

4. I will generally follow ancient tradition and include the Sun and Moon among the seven planets. When discussing details I will often need to distinguish the five starlike planets from the two great luminaries, the Sun and Moon. I will then refer to them as the other planets or, following Ptolemy, the five planets. *Almagest*, 9.1–6, 13.1–4.

a particular day. This astronomy, like other traditional astronomies, had no theoretical framework beyond the simple concept of dividing the year into equal parts.

Easter computus was also concerned with determining calendrically and ritually significant dates, the dates of the Paschal Full Moon and of Easter. These were computed using simple arithmetic and the periods of the Julian year, the lunar month, and the week. Although one result was an observable full Moon, these dates were computed using simple arithmetical techniques in which observations of the Sun and Moon had no direct part. Since the method of computus was fundamentally arithmetical, geometrical considerations of celestial spheres and circles could also be ignored. This does not mean that practitioners of computus never looked at the sky or considered geometrical models of the heavens. Observations and models were often discussed in the computistical literature to illustrate the celestial motions underlying the arithmetical techniques, but they belong more properly to other astronomical traditions.

Monastic timekeeping defined another astronomical tradition, again concerned with determining a ritual time, but here the time was the time of prayer. The techniques employed were observational, watching the course of the stars until they arrived at particular places that marked the time to pray; at first there was little in the way of a theoretical framework to govern these observations. This began to change early in the ninth century as instruments began to supplement simple unaided observations, bringing with them an implicit geometric model of the heavens and an increasingly quantitative measurement of the passage of time.

The final tradition is the one commonly taken as defining ancient and medieval astronomy, the geometrical astronomy of the quadrivium. The central concern of this tradition was the continuous motion of the heavens within a geometrical model of the universe. This tradition gave rise to two related branches. One was a qualitative cosmological model of a geocentric universe with rotating spheres carrying the stars and planets. The other was a predictive geometrical model of circles and epicycles and the mathematical techniques derived from that model to compute the positions of the stars, Sun, Moon, and other planets as functions of time. This tradition was not designed for, and in fact is not ideally suited for, determination of the arrival of particular days or moments that we have seen in the other three traditions.

Any attempt to treat medieval astronomy as a single tradition would pose an unnecessary dilemma. Either we would have to omit major elements of medieval astronomy as outside our concern, or we would find ourselves forcing elements from different traditions into a historically or theoretically inappropriate framework. Nonetheless, while distinguishing among these astronomies we also must remember that no intellectual tradition exists in total isolation; there are instances where these astronomies interact. Computus texts employ horizon observations to illustrate computistical concepts, while school commentaries in the liberal arts draw on data from computistical texts. Despite such interactions, more is to be gained from considering these four traditions separately than from indiscriminately lumping them together.

It is not just these astronomies, their questions and techniques, that concern us. Having identified these different astronomical traditions we find that they flourished in different cultural contexts, made specific contributions to the communities in which they flourished, and reflected and reinforced the values of the communities that supported them.

The traditional solar calendar, in both its prehistoric pagan and its medieval Christian form, was closely tied to local communities. Critical dates in a traditional solar calendar based on local horizon observations were transformed into feasts of important local saints that were sponsored by local elites and represented local, rather than universal, centers of temporal and spiritual power. Assemblies for their feasts on the traditional solar mid-quarter days animated and enriched the local centers of those cults.

While Easter computus also focused on religious rituals, its presentation of a uniform technique for calculating the date of a universal feast reflected the centralizing tendency and desire for uniformity of ritual on the part of the church hierarchy. This standard technique was spread by monastic and cathedral schools and by the Carolingian court, which also disseminated other elements of ritual uniformity.

Monastic timekeeping, like monasticism itself, combined elements of local autonomy with an underlying principle of order regulated by a sacred rule. The divinely ordained order of the stars was observed over local landmarks following local practices, yet all was aimed at following the same orderly round of prayer.

During late antiquity the astronomy of the liberal arts had lost contact, in the Latin West, with its powerful calculating techniques founded on spherical geometry and trigonometry. Since this tradition could no longer compute the precise circumstances of astronomical phenomena, it had lost its strongest connection to the observable sky. But the image it provided of a well-designed cosmos, and the concept that that cosmos is governed by a universal order, had lasting influence in court circles. To rulers the appeal of this image of universal dominion is obvious. That they chose to study this astronomy themselves and display it on ritual regalia and in the art they sponsored, so to be seen as wise rulers, suggests its value in justifying imperial dominion.

Considering these four traditions, the visage of early medieval astronomy becomes richer and more complex. These astronomies not only stimulated the quest for ancient learning from the tenth to the thirteenth centuries, they also provided the framework within which that astronomy was assimilated. Problems arising within the practical astronomies inspired the inquiry into and mastery of this newly recovered learning. These traditions, then, are essential not only for an understanding of early medieval science but also for a complete understanding of the development of science in the later Middle Ages and Renaissance.

In dealing with both popular and learned astronomies, we touch on an increasingly important historiographical issue: the interplay of learned and popular culture. Van Engen has recently surveyed this issue as it applies to the Christianization of western Europe, where the process of conversion is now recognized as a slow adaptation in which Christian and pagan concepts coexisted side-by-side for centuries.[5] In quite different guise this same concern appears in discussions of the folk astronomies of the Americas, where traditional astronomical techniques and their related rituals continued, often with a thin Christian veneer, in native communities.[6]

We find similar survivals in early medieval astronomy. Celtic feasts blend into saints' days; pagan constellations are used to determine the times for monastic prayer; quantitative data from Greek astronomy are employed to compute the date of Easter. The adoption of Christian beliefs and practices under the influence of preexisting pagan rituals, the adoption of Mediterranean geometric astronomy under the influence of traditional techniques, will provide one guiding theme to this discussion.

In tracing this theme I will be mindful of the interactions among different groups in society revealed by studies of the Christianization of Europe and of the close relationships between astronomy, religion, politics, and society revealed by studies of folk astronomies. Just as social historians have drawn insights into the structure of early medieval society from anthropological studies of traditional cultures, so can a historian of science better understand early medieval science by reflecting on archaeoastronomical and ethnographic investigations of astronomies in traditional cultures.

As an overview of a few important aspects of medieval astronomies spanning a millennium, this book cannot claim completeness. Medieval astronomy reminds me of a Mesoamerican jungle: here and there a few mounds indicate the sites of ruins, some of which have drawn explorers, while others remain to be investigated; much however has crumbled into ruin, been looted by scavengers, or lies forever buried. I have tried to find some pattern in the more readily visible monuments, but no doubt future investigators will examine those I have overlooked and find further paths connecting them. In particular, since the practice of astrology only begins to emerge at the end of this period, I have not dug deeply there. Something beyond Thorndike's monumental survey is still needed before we really understand medieval astrology.[7]

5. Van Engen, "Christian Middle Ages."
6. Broda, "Mesoamerican Agricultural Calendar."
7. Tester rightly criticized Thorndike and others who saw astrology where none was present through

It is a commonplace to acknowledge the inspiration of one's colleagues and teachers. Although I am taking something of a new approach, this debt is even more apparent. The question this book outlines has been nagging me since my first year as a graduate student, when the late William Stahlman introduced me to folk astronomies. The tools to attempt an answer I owe to David Lindberg and William Courtenay, who introduced me to medieval science and philosophy. My general framework of how astronomies, religions, and cultures interact has been refined by discussions with my friends and colleagues who do archaeoastronomy, especially Anthony Aveni, Johanna Broda, John Carlson, Davíd Carrasco, David Dearborn, and Clive Ruggles. As I placed elements of medieval astronomy in that framework a cautionary comment of the late Ned Zeena, a sun watcher of the tobacco clan at Walpi Pueblo, often came to mind. He recognized how I could see what he was doing as astronomy, but he looked at it as his religion. I have tried to be sensitive to such differences of perception.

One theme of this book is the support of learning through the Middle Ages; the book's appearance demonstrates that such support continues. This book first took form in 1988, during a sabbatical granted me by West Virginia University; years later its publication was assisted by a subvention granted by the university and its Eberly College of Arts and Sciences. Its completion would have been impossible without the assistance of the librarians and curators who granted me access to books and artifacts in their collections, frequently providing me with photographs to illustrate my discussion. I especially thank the tireless interlibrary loan staff of the West Virginia University Library, who cheerfully and efficiently met my requests for esoteric publications, as well as the librarians at St. Vincent Archabbey and College and the University of Pittsburgh, for their neighborly hospitality. Closer to home my son, Tom, brought order to my boxes of photocopies, my wife, Connie, brought clarity to my writing, and young Rose excused my absences. As the book developed, my students and colleagues commented on early drafts; their questions provoked me to define my argument more explicitly. Finally, I must thank the members of the community of medievalists who have edited texts, described artifacts, and looked in detail at aspects of my problem. The bibliography is not just a tool for those who read this book; it catalogs many of my debts. Perhaps this book will be accepted as partial payment.

"confusion of *astrologia* [often meaning astronomy] with astrology and the inference to the presence of astrology from descriptions or representations of the zodiac." Tester, *A History of Western Astrology*, pp. vii, 142. Flint's contention that the needs of religious timekeeping led churchmen to preserve astrology involves inferences of that kind. Flint, *Magic in Early Medieval Europe*, pp. 137, 142.

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