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'In So Many Ways Do the Planets Bear Witness': The Impact of Copernicanism on Judicial Astrology at the English Court, 1543-1660

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"IN SO MANY WAYS DO THE PLANETS BEAR WITNESS": THE IMPACT OF COPERNICANISM ON JUDICIAL ASTROLOGY AT THE ENGLISH COURT, 1543-1660

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ABSTRACT

The traditional historiography of science from the late-nineteenth through the mid-twentieth centuries has broadly claimed that the Copernican revolution in astronomy irrevocably damaged the practice of judicial astrology. However, evidence to the contrary suggests that judicial astrology not only continued but actually expanded during the sixteenth and early seventeenth centuries. During this time period, judicial astrologers accomplished this by appropriating contemporary science and mathematics. Copernicus's *De revolutionibus,* in particular, provided better mathematics for determining the positions of the planets than the prevailing Ptolemaic system and reformist astrologers interested in making astrology a precise, mathematical science embraced this new astronomy.

This study evaluates the impact that Copernicus's heliocentric theory of the cosmos had on the practice of judicial astrology, particularly within the English court patronage system between the publication of Copernicus's *De revolutionibus* in 1543 and the Restoration of the monarchy and founding of the Royal Society in 1660. In England, while noble patrons defined the value of science in terms of its practical utility, many English judicial astrologers successfully argued for scientific legitimacy based on their ability to precisely predict planetary locations. Contrary to their European counterparts on the Continent, English patrons typically required tangible, practical results to justify their support of client-scientists. The heliocentric theory received a largely positive reaction in England, and many astrologers readily employed its mathematics to make more precise

predictions of planetary locations, which would presumably lead to better prognostications of human events. As long as scientists and patrons defined science in these exclusively mathematical terms, astrology could comfortably exist within these scientific boundaries.

However, throughout the mid-sixteenth century, multiple processes occurred that changed astrology from a science into a popular belief in England. Patrons began to lose interest in astrology and thus financed fewer astrologers, and with the instability of the Civil War, fewer patrons were in positions of power to provide this sort of support. Furthermore, as astrology enjoyed increased popularity among the lower and merchant classes of England through almanac and pamphlet publications, scientists saw it in their best professional interest to consciously distance themselves from astrology and redefine and re-categorize it beyond the reasonable margins of proper scientific practice. In short, while astrology declined as a scientific activity during the latter half of the seventeenth century, it found success as a popular activity beyond the confines of conventional science.

DEDICATION

To my mother, for teaching me the love of reading;

to my father, for teaching me the love of the past;

and to Kirsten, for teaching me to love.

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INTRODUCTION

When Copernicus wrote in his seminal astronomical treatise *De revolutionibus orbium coelestium* that "in so many…ways do the planets bear witness," he was referring to how their observed motions provided evidence for the earth's mobility.[1] But for most of the scientifically-educated elite in sixteenth-century Europe, the planets bore witness in quite another way and provided evidence of a very different kind—that of their astrological influence over human events.[2] Copernicus's epoch-making work, of course, displaced the earth from the center of the cosmos and replaced it with the sun, but it also provided more precise calculations for the prediction of planetary positions than the Ptolemaic system. Among astrologers interested in applying this new astronomical data to the prognostication of human events, a great reform movement flourished throughout much of the sixteenth and early seventeenth centuries. Eventually, however, the reform movement foundered, scientists and their patrons lost interest, and astrology relocated to other more receptive venues. The narrative of astrology's scientific decline in the latter half of the seventeenth century is less a story about the elimination of a superstition and more a story about how science was defined, who defined it, and what values determined its definition. Most scientists accepted astrology in the early sixteenth century and most

[1] Nicolaus Copernicus, *De revolutionibus orbium coelestium* [1543],trans. Edward Rosen (Baltimore: Johns Hopkins University Press, 1978).

[2] See especially, Jim Tester, *A History of Western Astrology* (Suffolk, UK: Boydell Press, 1987), 197-201 and Hilary M. Carey, *Courting Disaster: Astrology at the English Court and University in the Later Middle Ages* (New York: Palgrave Macmillan, 1992), 92-116. Some later medieval and early modern rulers who were major proponents of astrology include Richard II of England, Charles V of France, Frederick II of the Holy Roman Empire, Ezzelino III da Romano of the March Treviso, as well as several Renaissance popes such as Innocent VIII, Leo X, and Paul III.

did not by the late seventeenth century—the responsibility for this lies not only in how astrology was reformed but also in how science was defined. What follows is an analysis of these two interconnected processes.

Credit for the "demise" of astrology is usually given to the disintegration of the Aristotelian-Ptolemaic cosmos, which was inaugurated by Copernicus and fulfilled by Newton. However, considerable evidence suggests instead that the Copernican theory did not hinder the major positions of astrology and in some cases, for a time, actually bolstered them. Given the fact that Copernicus's *De revolutionibus* offered a better mathematical model for determining the positions of the planets, its application in astrological texts should not be surprising; yet, few scholars have noted this with more than a passing interest. The traditional view of historians about Copernicanism and astrology argues that the Scientific Revolution in general and heliocentric astronomy in particular sounded the death knell for astrology as a serious academic discipline.[3]

Auguste Bouché-Leclercq's *L'Astrologie Grecque*, among the first works to view astrology in the context of the history of ideas rather than merely as a superstition, was typical of late nineteenth-century positivistic approaches to the history of science. Leclercq wrote that "once the Earth was reduced to the state of a planet and launched into space, the base [of astrology] was removed, and all the scaffolding crumbled at once" adding that there was a fundamental "incompatibility between astrology and the system

[3] See, for example, Don Allen Cameron, *The Star-Crossed Renaissance: The Quarrel about Astrology its Influence in England* (New York Octagon Books, 1941) and Theodore Otto Wedel, *The Medieval Attitude toward Astrology, Particularly in England* (New Haven: Yale University Press, 1920).

once proposed by Aristarchus of Samos, and since demonstrated by Copernicus."[4] Leclercq argued that the "celestial influence" of the stars required a geometric focal point, and the geocentric model of the cosmos provided this astrological requisite. Despite his reasonably fair assessment of astrology—as a strain of Western thought once believed by great men and thus worthy of careful study—Leclercq followed the progressive historiographical tradition and praised the demise of astrology as part of the story of scientific advancement.

Other historians from the early-twentieth century followed suit. Leclercq's contemporary Franz Cumont averred that "progress in astronomy" ultimately destroyed astrology by destroying the "false hypothesis on which it is based, namely the geocentric theory of the universe."[5] Unlike Leclercq, who confined his research to mathematical astrology, Cumont expanded this approach to include not only scientific issues related to the study of astrology but also its religious aspects. Cumont was interested primarily in the Greco-Roman era, which led him to study the syncretic aspects of astrology and its relationship to the religions of Late Antiquity, Mithraism in particular.[6] Though he did little research into early modern astrology, Cumont nevertheless mentioned Copernicus or heliocentrism over half a dozen times in his seminal work *Astrology and Religion*

[4] Auguste Bouché-Leclercq, *L'Astrologie Grecque* (Paris: E. Lerous, 1899), 626. *"Une fois la Terre réduite a l'état de planète et lancée dans l'éspace, la base se dérobant, tout l'échafaudage croula du même coup. Il n'y a d'incompatible avec l'astrologie que le systèm propose jadis par Aristarque de Samos, repris et démonstré depuis par Copernic."* My translation. All translations from French and Latin are my own or adapted from secondary sources unless otherwise noted. Sources of translations from all other languages are noted in the footnotes.

[5] Franz Cumont, *Astrology and Religion among the Greeks and Romans* (New York: Dover Publications, 1960), xi. Originally published in 1912.

[6] Although now nearly a century old, Cumont's works, particularly *Astrology and Religion among the Greeks and Romans*, remain among the most authoritative books on the subject. For a more recent work covering similar topics in ancient astrology, see also Tamsyn Barton, *Ancient Astrology* (London: Routledge, 1994).

among the Greeks and Romans, ending his work with the conclusion that "Copernicus and Galileo" destroyed the old "eschatological ideas" evinced by religious astrology by "overthrow[ing] the system of Ptolemy and bring[ing] down those heavens peopled by bright beings."[7] Though he wrote nothing of the direct effects of Copernicanism on astrology, Cumont characterized the Scientific Revolution as a shift in worldview in which the "mysterious prestige" accorded to the stars ultimately gave way to the "celestial mechanics" of modern astronomy.[8]

By the 1920s, heliocentrism's role in the downfall of scientific astrology was taken for granted by most historians. For example, in his now classic *Medieval Attitude toward Astrology*, Theodore Otto Wedel wrote that "the final disproof of astrology was never written," arguing that as long the Ptolemaic-Aristotelian model of the cosmos dominated the universities, "refutation was impossible."[9] Examining the decline of the Ptolemaic-Aristotelian version of the cosmos, which began with Copernicus, Wedel assumed that all fields of study using the geocentric theory ceased to function when those foundations were removed. Wedel added that "with the arrival of the new astronomy of Copernicus, [refutation] was no longer necessary."[10] Similarly, Christopher Macintosh considered the work of Copernicus, Kepler, and Galileo to have "rendered obsolete the cosmology on which astrology was based."[11] This traditional history, however, is wrong. Astrology remained a respected component of a typical early modern higher education

[7] Cumont, *Astrology and Religion among the Greeks and Romans*, 202.
[8] Ibid., xvi.
[9] Wedel, *The Medieval Attitude toward Astrology*, 89.
[10] Ibid.
[11] Christopher Macintosh, *The Astrologers and their Creed: An Historical Outline* (New York: Frederick Praeger, 1969), 77.

for well over a century after Copernicus's death and successfully incorporated the heliocentric theory.

Not all historians unquestioningly accepted this traditional assessment of the decline and ultimate failure of astrology nor did they note Copernicus or the Scientific Revolution as its principal undoing. As early as 1954, George Sarton issued a direct statement challenging this view, arguing that "the claims of astrology are independent of whether the earth or the sun is placed at the center" and reminding historians of science that "astrology did not disappear after the acceptance of the Copernican system but continued to grow abundantly."[12] Similarly, although Keith Thomas in his influential 1971 work *Religion and the Decline of Magic* repeated the conventional wisdom that "the intellectual pretentions of astrological theory were irreparably shattered" by the Copernican revolution, he qualified this assessment with the caveat that "heliocentrism was consistent with astrology" because the stars still exerted an influence over the earth no matter its position in the heavens—all that this new conceptual strategy required was a new set of calculations.[13] However, since Thomas's primary historical interests revolved around the social and religious implications of the rise of modern scientific thinking on popular beliefs, he proceeded no further with this line of thinking.

Finally, the writings of Eugenio Garin in the late 1970s and early 1980s, while repeating many of the same arguments of Sarton and Thomas, attempted to integrate the

[12] George Sarton, *Ancient Science and Modern Civilisation* (New York: Harper, 1959), 61. This book is made up of lectures Sarton delivered as part of the ongoing Montgomery Lecture series. The above quote comes from a lecture delivered at the University of Nebraska in 1954. See also Eugenio Garin, *Astrology in the Renaissance: The Zodiac of Life*, trans. Carolyn Jackson and June Allen (London: Routledge and Kegan Paul, Ltd., 1983), first published as *Lo Zodiaco della Vita*, x.

[13] Keith Thomas, *Religion and the Decline of Magic: Studies in Popular Beliefs in Sixteenth and Seventeenth Century England* (London: Weidenfield and Nicholson, 1971), 349.

history of astrology and particularly Renaissance astrology into the broader history of the Scientific Revolution. His most influential work *Astrology in the Renaissance* stands as a late addition in the backlash against the teleological progressivism of early- and mid-twentieth century histories of science. Historiographically, it also cautions of the dangers of what Maurice Mandelbaum called the "retrospective fallacy," a presentist bias in which the accomplishments of science in the past are judged historically important in proportion to their later corroboration.[14] Since modern historians viewed astrology as unscientific in the present, this preconception found its way into their assessment of astrology in the past. On the other hand, Garin argued for a great degree of continuity between medieval and early modern science, and used the Copernican impact on astrology as evidence of this point. He wrote that "if, after Copernicus had completely revolutionised the structure of the cosmos, and Kepler and Graz had still to adapt themselves once again to casting horoscopes, this only means that the origins of modern science did not come from either a radical break or from an instantaneous enlightenment."[15] To Garin, the continued existence of practicing astrologers after the Copernican revolution not only showed that the new cosmology could assimilate astrology but also disproved the very idea of a "revolution" in science. Nevertheless, none of these three scholars tackled the problem of how Copernicus or Copernican mathematics specifically affected the *practice* of astrology, confining their interpretations to the philosophical, religious, and cultural consequences of such a shift in worldview.

[14] See David B. Wilson, "The Historiography of Science and Religion," in *Science and Religion: A Historical Introduction*, ed. Gary B. Ferngren (Baltimore: John Hopkins University Press, 2002), 23; and Maurice Mandelbaum, *History, Man, and Reason: A Study in Nineteenth Century Thought* (Baltimore: Johns Hopkins University Press, 1971).
[15] Garin, *Astrology in the Renaissance*, 9.

The only scholar to directly address the impact of the Copernican theory on astrological practice was Mary Ellen Bowden. In her 1974 work *The Scientific Revolution in Astrology*, Bowden averred that astrology failed not due to anything intrinsically wrong with the system or to changes wrought by the new science of Copernicus, Galileo and Newton, but because it failed to undergo a revolution in the way that astronomy and physics did during this same period. Bowden explicitly argued that neither heliocentrism nor telescopic evidence proving the heavens were no longer immutable undermined the task of astrological reformers. Her research demonstrated how mathematical astrologers used empirical, experimental, and observational evidence to reform astrology during the Scientific Revolution. However, while Bowden focused on how the attempt at revolution failed, it is my intention to examine how practicing mathematical astrologers received the new Copernican mathematical models for the positions of the planets and how it affected their status as legitimate scientists. Given the resilience of astrology in the face of what, from the modern, rational perspective, seem to be insurmountable scientific obstacles, the impact of Copernicanism on early modern mathematical astrology deserves a more nuanced approach than it has received in these previous works.

Discussion of the issue of Copernicanism and its effects on astrology must contend with problems of indefinite terminology and the multiplicity of meanings of the term “astrology.” By the modern definition, astrology attempts to interpret the meaning of the positions and movements of celestial bodies, which are believed to have certain influences over the earth, in order to prognosticate future events or determine the characters or dispositions of human beings. During the early modern era, however, the

modern categories of astronomy and astrology were completely intertwined. Astrology, or *astrologia*, was the general term used to describe the study of the stars during this period.[16] This included two categories: judicial astrology and natural astrology. The natural branch of astrology dealt with the positions of the sun, moon, planets, and stars and the physical influences they exerted over the material world, including the change of the seasons, the prediction of eclipses, the positions and paths of the planetary orbits, meteor showers, the coming of comets, tides, and so on.[17] This knowledge—today classified broadly under the category of astronomy—contributed to the increased accuracy of calendars, indicated the best times for the planting and harvesting of crops, and improved navigation. On the other side, judicial astrologers studied the physical influence that the heavenly bodies exerted over people. This included the prognostication of major historical events, the preparation of horoscopes, the determination of auspicious moments for embarking on journeys, and the like.[18] In short, astrology could be used as

[16] I have attempted to retain traditional medieval and early modern terminology by referring to "astrology" as any area of study that has to do with the stars, regardless of whether or not it the foretelling of the future is involved. Astronomy and astrology did not distinguish themselves from one another until the late in the Scientific Revolution. "Astrology" encompassed both judicial astrology and natural astrology. Natural astrology and astronomy can be used interchangeably when they refer only to the study of the stars without regards to the influences they pose on human decision making, fate, and free will.

[17] David C. Lindberg, *The Beginnings of Western Science: The European Scientific Tradition in Philosophical, Religious, and Institutional Context, 600 B.C. to A.D. 1450* (Chicago: Chicago University Press, 1992), 274.

[18] Lindberg, *The Beginnings of Western Science*, 274; Tester, *History of Western Astrology*, 19 and 123; Wedel, *Medieval Attitude toward Astrology*, 27.The Greeks of the fourth and third centuries B.C.E. used the term *astrologia* to describe both the study of the movements of the heavens and the use of those movements to foretell future events, and this term remained intact into the early modern period. *Astronomia*, the origin of the English word astronomy, was rare in antiquity, and there was no clear attempt to distinguish them until Isidore of Seville's *Etymologiae* (ca. 630). Isidore defined *astronomia* as the study of the movements of the heavens and the naming of the stars and planets, while *astrologia* was divided into the physical study of the stars and planets, which remained virtually indistinct from *astronomia*, and the superstitious study, which he referred to as *mathematici*. The term *mathematici* was often employed to indicate those who prophesied by the stars during the late medieval and early modern era.

an umbrella term under which any discipline related to the study of the stars could be placed.

The dichotomization of astronomy and astrology into separate categories is instead a modern invention that does not characterize their relationship in the sixteenth century, and early sixteenth-century astrologers were often experts in "astronomical" knowledge. In the early modern era, judicial astrology required knowing the precise location of the sun, moon, and planets relative to the stars and the constellations. There were various forms of judicial astrology, which required knowledge of planetary positions at different times. For natal, or horoscopic, astrology, the positions of the celestial bodies at a subject's birth were necessary to make predictions. For horary astrology, astrologer-astronomers required the positions of these heavenly bodies at the time a particular question was asked, while electional astrology depended on knowledge of the future position of the stars and planets in order to determine the most propitious moment to get married or wage war.[19] Typically, rather than observing the heavens themselves, practicing astrologer-astronomers consulted tables which provided information on the location of celestial bodies at given times and places. Since the second century C.E., these tables had been prepared using the method of calculation developed by Ptolemy, an adherent of the geocentric model of the cosmos, whose *Almagest* and *Tetrabiblos* formed the backbone of early modern astronomy and astrology.[20]

[19] Benson Bobrick, *The Fated Sky: Astrology in History* (New York: Simon and Schuster Press, 2005), 22-26.
[20] Lindberg, 274-5; Tester, 12-13.

However, because Ptolemy's system was limited in its accuracy, the resulting tables contained errors which, while minuscule in the short term, accumulated over the course of several centuries. By the thirteenth century, Ptolemy's calculations were off by as much as two degrees of arc or four times the width of the moon.[21] While four times the width of the moon, or eight minutes, may seem trivial, it was enough to change sun and moon signs for some individuals born on the cusp between zodiacal signs or skew the results of electional astrology, which depended on knowing the precise time to complete a particular task. Furthermore, Ptolemy calculated the precession of the equinox at one degree for every one hundred years, rather than the actual figure of one degree per seventy-two years. Precession caused the ecliptic to slowly move westward against the fixed stars at this rate, causing the actual position of the ecliptic relative to the zodiac to be off by more than six degrees. Several attempts to rectify these calculations were made—most notably the Alfonsine tables, which were constructed between 1252 and 1270—but by the opening of sixteenth century, astrologers realized that the Ptolemaic system required more than merely revision.[22]

The new Copernican model of the cosmos provided more precise calculations for the positions of the planets, and many astrologer-astronomers used these calculations in order to maintain the scientific legitimacy they already possessed. Many judicial astrologers valued precision, in the sense of more reliable and more repeatable

[21] Thomas Kuhn, *The Copernican Revolution: Planetary Astronomy in the Development of Western Thought*, (Cambridge: Harvard University Press, 1957), 68-77; Thomas, *Religion and the Decline of Magic*, 288; Nicholas Campion, *A History of Western Astrology, Vol. 2: The Medieval and Modern Worlds* (London: Continuum Books, 2010), 106-111. See also James Evans, *The History and Practice of Ancient Astronomy* (Oxford: Oxford University Press, 1998), 262-266; and Bobrick, *The Fated* Sky, 23.

[22] Owen Gingerich, "Alfonso X as a Patron of Astronomy," in *Alfonso X of Castile, the Learned King (1221-1284)* (Harvard Studies in Romance Languages 43, 1990), 345.

predictions of the positions of the heavenly bodies, just as much as the ability of astrologers to make dependable predictions about human affairs. In this way, the Copernican system made judicial astrology measurable and repeatable—and hence more "scientific"—in that knowledge of the locations of stars and planets became more precise, even though these did not necessarily lead to more accurate predictions of human events. As Theodore Porter has argued, "there is a strong incentive to prefer precise and standardizable measures to highly accurate ones" because "accuracy is meaningless if the same operations and measurements cannot be performed" elsewhere.[23] When applied to early modern judicial astrology, this suggests that accurate prognostication would be difficult to define if the methods used to arrive at these predictions did not employ the most precise observational data. Eventually, precision regarding the positions of the planets became "standardizable" as Copernican—and later Keplerian and Galilean—astronomy rendered these calculations repeatable. Perhaps most importantly, predictions of the positions of the planets were convincing to patrons for whom practical results were becoming the defining standard of value. In the words of Stephen Pumphrey and Frances Dawbarn, "patrons…wanted proof" as their criteria for acceptable scientific practice, and by that standard, the Copernican theory did contribute to astrological legitimacy.[24]

English astrologer-astronomers during roughly the century between the publication of Copernicus's *De Revolutionibus* and the Civil War stand out as a particularly pertinent case study because their burgeoning interest in practical,

[23] Theodore Porter, *Trust in Numbers: The Pursuit of Objectivity in Science and Public Life* (Princeton: Princeton University Press, 1995), 29.
[24] Stephen Pumfrey and Frances Dawbarn, "Science and Patronage in England, 1570-1625: A Preliminary Study," *History of Science*, Vol. 42 (2004): 141.

mathematical methods was reinforced by the pragmatic tendencies of the English court patronage system. Patronage systems in early modern Europe have been classified, in the terminology of Pumfrey and Dawbarn, as either "utilitarian" or "ostentatious."[25] The purpose of the ostentatious model was to exalt the cultural prestige of the patron. Utilitarian patronage, on the other hand, existed to benefit the patron in tangible ways: to increase their financial wealth, enhance their prowess on the battlefield, or improve navigational aptitude for their overseas ventures. Judicial astrology could exist comfortably within either patronage system depending on the practitioner or the patron. While the continental model of patronage, particularly in the Holy Roman Empire and the Italian city-states, prized the ostentatious system, the English court embraced the utilitarian.[26] Because many English judicial astrologers successfully argued for scientific legitimacy based on their ability to precisely predict planetary locations, English patrons regarded their services as a practical utility that conformed to the methodology of science. I will argue that as utilitarian patronage came to dominate the English system in the sixteenth century, astrologers used Copernican precision to gain status as scientific and attract the attention of patrons. Among early modern English scientists, it eventually became a problem that post-Copernican precision in the prediction of planetary locations

[25] Ibid., 137.

[26] For examples of the ostentatious patronage system, see especially, Mario Biagioli, *Galileo, Courtier: The Practice of Science in the Culture of Absolutism* (Chicago: University of Chicago Press, 1993); Paula Findlen, *Possessing Nature: Museums, Collecting, and Scientific Culture in Early Modern Italy* (Berkley: University of California Press, 1994); and William Eamon, *Science and the Secrets of Nature: Books of Secrets in Medieval and Early Modern Culture* (Princeton: Princeton University Press, 1994). Less work has been done on the more utilitarian system. One good introduction is Bruce T. Moran, ed., *Patronage and Institutions: Science, Technology, and Medicine at the European Court, 1500-1750* (Suffolk, UK: Boydell Press, 1991). See especially, Lesley B. Cormack, "Twisting the Lion's Tail: Practice and Theory at the Court of Prince Henry of Wales," 67-84; David S. Lux, "The Reorganization of Science, 1400-1750," 185-194; and A.J.G. Cummings and Larry Stewart, "The Case of the Eighteenth-Century Projector: Entrepreneurs, Engineers, and Legitimacy at the Hanoverian Court in Britain," 235-261.

did not lead to greater accuracy in the prognostication of human events. However, since human events were so difficult to quantify, judicial astrologers eager to make their practice scientific ignored this in favor of what could be reliably measured. This changed when the focus of scientific activity moved beyond the English courts to the universities and Royal Society and judicial astrology became the domain of the popular classes in the second half of the seventeenth century. Then, it was in the interest of practicing scientists to distance themselves from astrology and redefine it as outside the boundaries of legitimate science.

This study examines the impact of Copernicanism on judicial astrology within the English court patronage system between the introduction of heliocentrism to England in 1540s through roughly the reign of Charles I, though I will place significant focus on the Elizabethan and Jacobean eras. While this may seem like an arbitrary place to end this study, the main reasons for limiting it in this way is because the patronage system on which I focus began to decline in importance following the Restoration in 1660 as the locus of scientific activity shifted from noble courts to universities and the newfound Royal Society.[27] Chapter One provides a brief history of astrology from its origins in ancient Babylon and outlines its state at the time of Copernicus, paying particularly close attention to the "crisis" of fifteenth- and sixteenth-century astrology—as it was described by many writers at the time—because many of the issues of precision, accuracy, and repeatability with which English astrologers were faced emerged out of this earlier generation. The chapter ends with a brief retelling of the story of Copernicus's

[27] Bernard Capp, *English Almanacs, 1500-1800: Astrology and the Popular Press* (Ithaca, NY: Cornell University Press, 1979), 286-190.

publication of *De revolutionibus*, well-trodden ground to be sure, but it is necessary in order to expand upon its particular importance within the astrological world. Chapter Two relates the history of the reception of the heliocentric theory in England from its first appearance in print in 1556 to its first unqualified acceptance as a physical reality in 1576 to its acceptance based on observational evidence in the 1610s. Chapter Three deals with the appropriation of Copernican mathematics in service of astrology, specifically within the context of the patronage system in England and the court culture of both nobles and monarchs during the late Tudor and early Stuart ages. Finally, Chapter Four continues this story up through the 1650s and compares mathematical astrology as it was practiced in the courts with other institutional contexts during the same era—primarily in universities, in almanacs, in popular culture, and among the great exchanges between men of letters who argued for and against astrology based on their own experience within these institutions.

Many histories of astrology that take their story through the early modern era find it obligatory to end with a narrative of astrology's decline and ultimate demise in the late seventeenth century as a matter of necessity. After relating astrology's three-and-a-half millennia historical success, they often end on a gloomy note, describing its failures in the late seventeenth century, or conversely, they end with a celebratory tone of scientific triumphalism. In either case, the story simply ends. The superstition has been overcome; the light of rationality has finally shone through. The formula for writing historically about astrology usually ends long before the modern era, and it ends in failure.

In a sense, for this paper, I have turned this formula on its head, instead beginning with astrology's failures and ending my own narrative with its greatest successes, or at least its re-categorization into a field that allowed it to find success outside of the scientific mainstream. By failures, I mean the difficulties in mathematical and observational precision with which astrologers had to contend in the early modern era, and by success, I refer to astrology's rise in popularity among the newly literate classes of the mid-seventeenth century just as it was being abandoned by scientists for being unscientific. Failure, however, is too strong a word. Astrology did not fail—it merely ceased to be a science.

CHAPTER ONE

FROM PTOLEMY TO COPERNICUS:

A BRIEF HISTORY OF ANCIENT AND MEDIEVAL ASTROLOGY

Astrology has a long and complex history, and it will be useful to track its development from its origins in second millennium B.C.E. Mesopotamia to the Renaissance era of "crisis" before describing the impact of Copernicanism on its practice. From the end of the Roman Empire until the Later Middle Ages, most objections to astrology were religiously motivated, and in general, revolved around the issue of preserving the free will of the individual and the power of God over the world. By the fourteenth century, skeptical scholars began to attack it for its lack of scientific rigor and its failure to properly use mathematics. It was into this intellectual climate that Copernicus emerged as an astronomer concerned with constructing a mathematically precise model of the movements of the heavenly bodies, and while he appears to have had little interest in astrology, the problems that astrologers faced during his lifetime were the same ones he tackled when he set out to revise the Ptolemaic-Aristotelian system.

Astrology had many independent origins chronologically and geographically, but the Western version had its foundations as an organized discipline in Babylonian Mesopotamia around 1800 B.C.E. and arose simultaneously with the Babylonian creation of the first star charts in global history.[28] Generally speaking, astrology enjoyed

[28]Otto Neugebauer, *The Exact Sciences in Antiquity* (Providence, RI: Brown University Press, 1957), 97.

unquestioned legitimacy in ancient Mesopotamia because it grew out of both the Babylonian religious tradition and the astronomical tradition. The Babylonian religion considered the stars and planets divine, and this religious devotion to the heavens led to meticulous study. Because of this integration of religious and scientific ideas about the power of the planets, Babylonians believed that the heavenly bodies exerted influences over human affairs.[29]

Although the foundations of Babylonian astrology had been laid in the second millennium B.C.E., for nearly a thousand years, Babylonian astrology remained entirely "mundane," meaning that astrologers predicted only events for nations or the world at large, rather than casting horoscopes for individuals.[30] Babylonian astronomers were able to predict the positions of the sun and moon and the dates of eclipses with a great deal of accuracy, but they were less adept at predicting the positions of the planets, and their ability to predict the positions of the sun and moon were never applied in any technical sense to draw individual horoscopes.[31] The most important concern in the Babylonian version of astrology was to create accurate calendars, which served religious or ceremonial purposes.[32] An interest in planetary motion and the ability to determine their locations with some degree of precision finally began to emerge in Mesopotamia around the eighth century B.C.E., and this form of astrology made its way westward to the

[29] Like the Greeks and Romans later, the Babylonian names of the planets corresponded to deities in their pantheon: Mercury was identified with Nabu, Venus with Ishtar, Mars with Nergal, Jupiter with Marduk, and Saturn with Ninurta.
[30] Tester, *History of Western Astrology*, 13-15.
[31] Ibid., 11; Neugebauer, *Exact Sciences in Antiquity*, 116-19.
[32] Tester, *History of Western Astrology*, 12; Neugebauer, *Exact Sciences in Antiquity*, 80.

ancient Greeks over the next several centuries.[33] The mathematical techniques and observational precision necessary for constructing tables indicating the positions of heavenly bodies, drawing nativities, and casting horoscopes—those things now most associated with astrology—materialized around the fourth century in Greece.[34] Though the Babylonians had begun this process, their lack of interest in the movement of the planets meant that the methods of later medieval and early modern astrology were not present in the ancient Near East and did not emerge until the Hellenistic era.

Hellenistic astrology, which would develop and expand upon the techniques of charting stars, drawing nativities, and casting horoscopes, laid the groundwork for the type of astrology that would flourish for nearly two millennia in Europe.[35] Although their founders showed little interest in the practice of astrology, Pythagorean, Platonic, and Aristotelian schools of thought, in their later forms, all came to accommodate astrological discourse within their cosmologies.[36] All of the major precepts of astrology were logically consistent with these worldviews and within these frameworks, particularly the Aristotelian conception of the cosmos, astrology was able to thrive. From the Hellenistic era to the early modern era, the principles of astrology became intertwined with Aristotelian cosmology and this cosmological schema provided a system within which astrology made sense.

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[33] Lindberg, *Beginnings of Western Science*, 274.
[34] Tester, *History of Western Astrology*, 12-13.
[35] Ibid., 12; Neugebauer, *Exact Sciences in Antiquity*, 170. While Neugebauer obviously accepted the Babylonian origins of astrology, he argued that "the main structure of [modern] astrology is undoubtedly Hellenistic."
[36] Tester, *History of Western Astrology*, 12-13; Bobrick, *The Fated Sky*, 15-20.

Aristotle's cosmos consisted of concentric spheres with the earth at the center and a sphere of fixed stars at the outermost reaches. Physical laws acted differently depending on an object's position within the cosmos. The supralunar sphere, the entire universe above the moon, was an incorruptible, unchangeable realm where all movement was perfectly circular and, in general, predictable. Birth, generation, decay, and death, on the other hand, characterized the sublunar region. It was a world of transience.[37] The predictability of the movements of the stars and planets in the supralunar sphere, the obvious parallels between the movement of the sun across the ecliptic and the changing of the seasons, and the relationship between the moon and the tides, among other things, led astrologers to the conclusion that the heavens exerted an enormous influence over all aspects of the sublunar sphere.[38] Moreover, the general predictability of events in the supralunar sphere, combined with their observed impact on the sublunar sphere, caused astrologers to envision a relationship between the upper and lower spheres suggesting that the heavens were the key to predicting all sublunar activity. As events in the heavens became more predictable, astrologers believed that this knowledge could be employed to make the sublunar realm more predictable as well.

As Aristotelian natural philosophy was adopted by the Romans throughout the last two centuries before Christ, astrological writings flourished, and astrologers took Aristotelian physical and geocentric cosmology as the underpinning of their astrology. During the early empire, especially in Eastern, Hellenistic scholarly centers such as

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[37] Lindberg, *Beginnings of Western Science*, 55. The Aristotelian works most responsible for this worldview were *De Caelo* (*On the Heavens*), *Physica* (*Physics*), and most especially *De Generatione et Corruptione* (*On Generation and Corruption*). See also *The Basic Works of Aristotle*, ed. Richard McKeon (Chicago: Random House, 1941).

[38] Lindberg, *Beginnings of Western Science*, 274-77.

Alexandria, a number of astrological texts were produced that began to form an orthodox version of astrology. For example, Marcus Manilius's *Astronomicon* (ca. 10 C.E.), an astrological textbook written in Greek hexameter verse, provided the first account of the signs of the zodiac as they are known today, as well as the first account of casting horoscopes based on planetary positions within these "houses."[39] Dorotheus of Sidon's didactic five-part poem the *Pentateuch* (ca. 75 C.E.) delineated the different varieties of astrology, dividing its practice for the first time into natal, hoary, and electional varieties. Vettius Valen's encyclopedic compilation, the *Anthology* (ca. 150 C.E.), provided numerous techniques for forecasting horoscopes and included several example horoscopes and natal charts. The most important work—both at the time and in later centuries—was the *Tetrabiblos* by the Hellenized Egyptian Ptolemy (90-168 C.E.), which became the cornerstone of astrology in the medieval and early modern eras.[40] In conjunction with Ptolemy's other great work, the *Almagest,* which described the geocentric universe mathematically, the *Tetrabiblos* constituted a formidable edifice of astrological authority.[41]

Within the *Tetrabiblos,* Ptolemy treated astrology hierarchically, beginning with the general and working toward the particular. Book I offered procedural rules for prognostication, describing the movement of the planets and stars, the use of calculations, and how to understand the results. Book II detailed the collective aspects of astrology

[39] Tester, *A History of Western Astrology*, 30-42.
[40] Ibid., 11-56.
[41] Wedel, *Medieval Attitude toward Astrology*, 65 and 67. The *Almagest*, from the Arabic *al-majistī*, or "the greatest," was the name given to the book by its later Arabic translations. Among the Alexandrian Greeks it was known as the *Mathēmatikē Syntaxis* (Μαθηματικη Σύνταξις). The *Tetrabiblos*, from the Greek meaning "the four books" was also known to the Latin-speaking world as the *Quadripartitum*.

generally applicable to large populations or nations, and Books III and IV together offered more specific details of individual astrology, or those things which may be determined by the positions of the stars and planets at the conception, birth, and other important moments in the life of the person whose horoscope has been cast.[42] The *Tetrabiblos* achieved popularity in part because, unlike some other Hellenistic works on astrology, it did not delve into the complicated mathematics astrology had developed by the first century C.E. but rather presented a history of astrology and systematized and simplified the great mass of detailed information about the science.[43] However, Ptolemy's *Almagest*, which provided the requisite astronomical data for the astrological topics presented in the *Tetrabiblos*, delivered the specific corresponding mathematical information needed to calculate the positions of the planets and stars in order to put the *Tetrabiblos* into practice.[44] Ptolemy defined astrology in terms that made it wholly natural and scientific, consciously eliminating the "mystical" elements it retained in other versions. In fact, he rejected much of the traditional astrology that had been popular during the Hellenistic era.

In the *Tetrabiblos*, astrology emerged as a mathematical, natural science intimately connected to the Aristotelian worldview, and the Ptolemaic-Aristotelian cosmos that arose in the first century C.E. became the dominant astronomical and astrological system until the sixteenth century. Moreover, Ptolemy defined astrology in a way that promoted it as a science as opposed to a divinatory or semi-religious practice.

[42] Tester, *History of Western Astrology*, 68.
[43] Ibid., 68-70.
[44] See Olaf Petersen, *A Survey of Ptolemy's Almagest* (New York: Springer, 2010), 400-9.

"As for the nonsense on which many waste their labor and of which not even a plausible account can be given," Ptolemy wrote, referring to those whose adherence to astrology was motivated by religious devotion, "this we shall dismiss in favor of the primary natural causes."[45] While Ptolemy insisted that astrology had to follow the rules of science, he conceded that astrology was at best a conjectural rather than exact science. However, he considered the determination of the precise positions of the heavenly bodies as the key to making astrology scientific and making predictions as accurate as possible:

> Prognostication made by persons of this class [non-scientists] must be frequently fallacious, owing to their deficiency in science and their consequent inability to give necessary consideration to the time and place, or to the revolutions of the planets; all which circumstances, when exactly defined and understood, certainly tend towards accurate foreknowledge.[46]

Ptolemy criticized "the scientific vanity" of those astrological practitioners who attempted to prognosticate without the use of accurate star charts because "they receive no confirmation from nature" and their techniques "are not capable of being rationally demonstrated."[47] Without prognostication based on the scientific observation of the stars, Ptolemy regarded any astrology as illegitimate and incapable of rendering accurate predictions of human events.

Ptolemy's purpose in writing the *Tetrabiblos* was to place astrology within the cosmological framework of Aristotelianism and the philosophical framework of

[45] Ptolemy, *Tetrabiblos*, ed. and trans. F.E. Robbins (Cambridge: Harvard University Press, 1940), 237 (Book 3, Chapter 3).
[46] Ptolemy, *Tetrabiblos*, ed. and trans by J.M. Ashland (Chicago: Aries Press, 1936), 4 (Book 1, Chapter 2). I have use Ashland's translation for most of my research. However, due to his frequent abridgment and omission of crucial passages, I have used Robbins's translation for the Loeb Classical Library to supplement that of Ashland. The particularly translation is marked in all notes.
[47] Ibid., 37-8 (Book 1, Chapter 27). Ashland's translation.

Stoicism.[48] The philosophy of Stoicism, which was at its peak during the first century C.E., aligned with astrology quite well. Its insistence on the power of fate, the deterministic nature of the universe, and the individual's ability to adjust his will to be in harmony with this universe mirrored the type of astrology that Ptolemy attempted to cultivate. With astrology as a scientific enterprise, practitioners could attain some knowledge to gain control over the uncontrollable and inexorable forces of the universe. And with the procedural rules of the *Tetrabiblos* and the observations and calculations of *Almagest*, the dual studies of astrology and astronomy rested firmly on a geocentric, Ptolemaic-Aristotelian foundation for the next fifteen hundred years.

With the Christianization of Europe and the dissolution of the Roman Empire, astrology, like much other learning in the Latin West, became dormant. The Christian attitude toward astrology was varied and ranged from qualified approval to outright rejection. Typically, Christian arguments against astrology consisted of general complaints that as a pagan science, practicing astrology amounted to a form of heresy. The other principal complaint was that astrology contravened free will, which was crucially important for Christians who believed that it was through individual free will that Christians could choose to follow Christ.[49]

In spite of these complaints, astrology survived and gained some degree of respectability in the new Christian intellectual environment of medieval Europe. By the

[48] Tester, *History of Western Astrology*, 68-70. For the Stoic influence over physical science in the early modern era, see also Peter Barker, "Présences de la Physique Stoïcienne dans la Philosophie Naturelle aux XVIe et XVII Siècles," *Revue d'Histoire des Sciences* 61 (2008): 265-286.

[49] This was the official, Augustinian position of the Catholic Church. The more deterministic Calvinist position on predestination, of course, emerged later. Ironically, Calvinists were among the least receptive to astrology among Protestant religious sects.

fifth century, the seven liberal arts had ascended to prominence as the essential educational curriculum for the clergy.[50] The seven liberal arts consisted of the trivium of grammar, rhetoric, and dialectic, followed by the more advanced quadrivium of arithmetic, geometry, music, and astronomy. The science of astrology survived as a subfield of astronomy in the medieval curriculum.[51] Furthermore, as medieval historian Valerie Flint has argued, astrology survived in the early Middle Ages precisely *because* it could be employed to combat what many Christian authorities considered even more dangerous forms of magic. Flint claims that astrology was rehabilitated during the Middle Ages because it was "Christianized" and used against what Christian thinkers perceived to be far more dangerous challenges to the Church, such as witchcraft, demonology, or the use of illicit magic.[52] The mathematical practice of astrology and the technical knowledge required to fully understand it exercised the mind to a high degree, which appealed greatly to early medieval clerics who emphasized the more ascetic life of the monasteries. Additionally, the use of astronomical data was essential for calculating the canonical hours of prayer and dates of moveable feasts such as Easter. This assured that the framework of astrology remained intact throughout the Middle Ages.

Although astrology retained this respectability, it was criticized on religious grounds. The Christian writers of the first few centuries after Christ, especially the Church Fathers and Augustine of Hippo in particular, urged new Christians to abandon old pagan superstitions such as astrology in favor of free will and the option of salvation

[50] C. Warren Hollister and Judith Bennett, *Medieval Europe: A Short History* (New York: MacGraw Hill, 2002), 250.
[51] Tester, *History of Astrology*, 101-2.
[52] Valerie I.J. Flint, *The Rise of Magic in the Early Middle Ages* (Princeton: Princeton University Press, 1991), 100-150.

through Christ. Augustine had dabbled in many philosophies in the personal quest that would eventually lead him to Christianity, including Manichaeism and Greek skepticism, both of which were more receptive to astrology. Augustine criticized astrology on religious grounds, arguing that "a devout Christian must avoid astrologers and all impious soothsayers, especially when they tell you the truth, for fear of leading his soul into error by consorting with demons and entangling himself with the bonds of such association."[53] Significantly, in his denunciation, Augustine also appealed to reason and logic to counter the argument for astrology. Twins, he wrote, were by definition born at a time when the stars should rule over them in identical ways and that if astrology were a valid science then we should expect to see them live their lives with comparable personalities, social statuses, and fates. However,

> [The astrologers] have never been able to explain why twins are so different in what they do and achieve, in their professions and skills, in the honors they receive, and in other aspects of their lives and deaths. In all such matters, twins are often less like each other than complete strangers; yet, twins are born with practically no interval of time between their births and are conceived in precisely the same moment of a single sexual semination.[54]

Augustine attributed the occasional success of astrologers to simple luck and said "that guesswork was often borne out of mere chance. If an astrologer made a great many predictions, several of them would later prove to be true, but he could not know it at the

[53] Augustine of Hippo, *The Literal Interpretation of Genesis*, Vol. 1, ed. and trans. John Hammond Taylor (Mahwah, NJ: Paulist Press, 1982), 72-3 (Book 2, Chapter 17). "*Quapropter bono christiano, sive mathematici, sive quilibet impie divinantium, maxime dicentes vera, cavendi sunt, ne consortio daemoniorum animam deceptam, pacto quodam societatis irretiant*." The translation is Taylor's.

[54] Augustine of Hippo. *City of God*. trans. by Demetrius B. Zema and Gerald G. Walsh (New York: Fathers of the Church, 1950), 243 (Book 5, Chapter 1). This is also quoted in David C. Lindberg, "Science and the Early Christian Church," *Isis* 74 (1983): 509-530.

time and would only hit upon them by chance."[55] Augustine argued, with reference to Hippocrates, that the more likely explanation for the similarity in the life twins was that they shared similar medical circumstances "since their parents' condition at the time of conception could easily affect the embryos, and it would be no wonder if the twins should be born with the same kind of health, since they had developed in the same way in their mother's womb."[56] In other words, there were many explanations to account for similarities among individuals born at the same time that did not require resorting to astrological influence.

Despite his unwavering dismissal of astrology as way to foretell the future, Augustine, like most other Christian thinkers with a classical education, affirmed that the stars could in fact have an influence on the earth and the material of the sublunar sphere and that this could affect man insomuch as man was subject to the happenings of nature. "It is not absurd to say, with reference only to physical differences," wrote Augustine,

> that there are certain sidereal [stellar] influences. We see that seasons of the year change with the approach and the receding of the sun. And with the waxing and waning of the moon, we see certain kinds of things grow and shrink, such as sea urchins and oysters, and the marvelous tides of the ocean. But the choices of the will are not subject to the positions of the stars.[57]

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[55] Augustine of Hippo, *Confessions,* trans. by R.S. Pine-Coffin (New York: Penguin, 1961), 140 (Book 7, Chapter 6).

[56] Augustine, *City of God*, 244 (Book 5, Chapter 2).

[57] Augustine of Hippo, *City of God*, 251 (Book 5, Chapter 6). "*Cum igitur non usquequaque absurde dici posset ad solas corporum differentias adflatus quoasdam valere sidereos, sicut in solaribus accessibus et decessibus videmus etiam ipsius anni tempora variari et lunaribus incrementis atque detrimentis augeri et minuiquaedam genera rerum, sicut echinos at conchas et mirabiles oceani, non autem et animi voluntates positionibus siderum subdi…*" The translation is Zema and Walsh's. See also David C. Lindberg, *The Beginnings of Western Science*, 277. Augustine had been less dismissive of the comparable concept of fate, by which he meant that which "happens without cause or rational explanation, and that fate is what is bound to happen, in spite even of the will of God or of men," but he stated that the disparity was only in the symbol used to describe those acts which seemed to happen randomly. Among those who regarded such acts as the will of fate "but mean by fate the will and power of God, they should keep their conception, but

Man's will was untouchable, but his body, being simply matter, was susceptible to astrological authority. Augustine consciously demarcated natural and judicial astrology in his criticism, allowing for the former while condemning the latter. The basis of Augustine's argument—that judicial astrology flouted Christian free will—became standard among those who attacked astrology throughout the Middle Ages, and many astrologers went to great lengths to demonstrate that their astrological predictions allowed for free will. Provided that they avoided this trapping and properly qualified astrology to acquiesce to free will, astrologers continued to practice largely unabated throughout the Middle Ages.

By the fourteenth century, astrology was practiced as a science at royal courts and in universities but had begun to come under attack by skeptical scholars on scientific as well as theological grounds.[58] Beginning in the Later Middle Ages, the terms of the controversy transformed into a scientific debate about the legitimacy of astrology's mathematical techniques. For example, Nicole Oresme, an especially vociferous opponent of judicial astrology, argued that natural astrology was grounded in mathematics, but complained that judicial astrologers rarely applied this to their practice. In his *Livre de Divinacions* of ca. 1365, Oresme, like Augustine, acknowledged that "[natural] astrology is speculative and mathematical, a very noble and excellent science and set forth in the books [of astrology] very subtly, and this part can be adequately known," but he argued that using this knowledge to make prognostications about human

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change their expression." ("*…esse fortuita quae vel nullas causushabent vel non es aliquot rationabili ordine venientes, et ea fatalia quae praeter Dei et hominum…Quae si propterea quisquam fato tribuit, quia ipsum Dei voluntatem vol potestatem fati nomine appellat, sententiam teneat, linguam corrigat.*")

[58] See especially Tester, *History of Western Astrology*, 197-201 and Carey, *Courting Disaster*, 92-116.

events was futile because the positions of the heavenly bodies "cannot be known precisely and with punctual exactness, as I have shown in my treatise on the Measurements of the Movements of the Heavens and have proved by reason founded on mathematical demonstration."[59] Oresme continued that not only did astrologers lack the necessary mathematical precision to apply planetary positions to foretelling future events, but also that those that were known were outdated:

> We know too little about it and in particular the rules in the book are false…and have either slight proof or none. And some of them which were fulfilled in the place or at the time when they were laid down are false in other places or at the present time: for the fixed stars which according to the ancients have great influence are not now in the position that they were in then and these same positions are used in making predictions.[60]

Oresme claimed that lack of rigor and scientific precision was exactly what made astrology such an illegitimate discipline in the first place, since "the rules of astrology are based on poetry and rhetoric" rather than on hard, mathematical science.[61] Oresme

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[59] Nicole Oresme, *Livre de Divinacions*, in *Nicole Oresme and the Astrologers*, ed. by G.W. Coopland (Liverpool, UK: Liverpool University Press, 1952), 55. "*La premiere partie d'astrologie est speculative et mathematique, tres noble et tres excellente science, et baillie es livres moult soubtilment et la puet on suffisament savoir, mais ce ne puet ester precisement et a point, si comme j'ay declaire en mon traictie de la Mesure des Mouvemens du Ciel et l'ay prouve par raison fondee sur demonstracion mathematique*." The translation is Coopland's. His work is a side-by-side Middle French to English translation. The *Livre de Divinacion* itself was a Middle French version, though not a word-for-word translation, of his earlier Latin work, *Tractatus contra astronomos.* Oresme is one of the few scholars from the Later Middle Ages who wrote in a language other than Latin. He wrote in Middle French because the people he most wished to read it—the noblemen of the court of King Charles V—knew no Latin, and he claimed that he composed "this little book so that laymen may understand" the futility of astrology and overcome their "stupidities." See also Joan Cadden, "Charles V, Nicole Oresme, and Christine de Pizan: Unities and Uses of Knowledge in Fourteenth-Century France," in *Texts and Contexts in Ancient and Medieval Science*, ed. Edith Sylla and Michael McVaugh (Leiden, Netherlands: Brill Academic Publishers, 1997), 226.

[60] Nicole Oresme, *Livre de Divinacions*, 55. "*…on en scet trop peu mesement, car le plus des regles qui sont es livressont faulses…et petitement ou nullement prouvees. Item, aucunes avoient lieu ou paiz ou au temps qu'elles furent faites qui sont faulses aulleurs et maintenant. Car les etoilles fiches qui sont de grant influence selon les anciens, d'apres s'appliquent a la pratique des jugement.*" The translation is Coopland's.

[61] Ibid., 87. "*…des regles d'astrologie sont fondees sur poetrie et sus rethorique…*" The translation is Coopland's. See also Cadden, "Charles V, Nicole Oresme, and Christine de Pizan," 228.

attacked astrology on the grounds that it lacked the mathematical precision necessary to determine exactly where the heavenly bodies were at any given time, and this meant that astrologers' "predictions…were variable and discordant."[62] Since "the disposition of the heavens cannot be completely known" according to Oresme, then these "fables and imaginings…cannot be accepted as a natural science."[63] Without experimental, observational, or mathematical proof, Oresme concluded that judicial astrology was not a science. The criticism that astrology was too imprecise mathematically to be considered a legitimate science became a typical approach to denouncing it up to the time of Copernicus.

Perhaps the most scathing critique of astrology written during the early modern era, and certainly among the most influential throughout the sixteenth and seventeenth centuries, was the *Disputationes adversus astrologiam divinatricem* by the Italian humanist philosopher Giovanni Pico della Mirandola.[64] While Pico seems to have been motivated by his concerns that astrology was an unchristian practice, his attack thoroughly covered all of the major arguments against astrology, including a lengthy section on its unscientific basis and its lack of mathematical precision. Interestingly, Pico approved of magic, which he defined as man's harnessing the power of the universe,

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[62] Ibid. "*…ilz estoient en leurs jugemens variables et discordans…*" My translation.

[63] Ibid. "*…que la disposicion du ciel et des estoilles ne peut ester sceue a plain…sus fables et sus persuasions qui ne sont pas a recevoir en naturelle science*." My translation.

[64] For a good overview of Pico's life and thought, see Paul Oskar Kristeller, *Pico della Mirandola: Introduction*, trans. Elizabeth Livermore Forbes, in *The Renaissance Philosophy of Man*, ed. Ernst Cassirer, Paul Oskar Kristeller, and John Herman Randall, Jr. (Chicago: University of Chicago Press, 1948), 215-222. For a summary and analysis of Pico's *Disputationes adversus astrologiam divinatoricem*, see Don Allen Cameron, *The Star-Crossed Renaissance: The Quarrel about Astrology and its Influence in England* (New York: Octagon Books, 1941), 19-35; Wayne Shumaker, *The Occult Sciences in the Renaissance: A Study in Intellectual Patterns* (Los Angeles: University of California Press, 1974), 16-27; and Eugenio Garin, *Astrology in the Renaissance*, 77-99.

while he deplored astrology because he considered it man's submission to the will of the universe.[65] He spent much of his *Disputationes* differentiating between the two.

Pico focused his attack primarily on judicial astrology, but he asserted that improper definitions for astrology were among its greatest problems. He confined his critique to astrology "which foretells things to come by the stars" rather than astronomy, which he defined as "the mathematical measurements of the stellar sizes and motion, which is an exact and noble art."[66] However, Pico took issue with astrologers because they took no heed of these measurements and instead relied on an amorphous set of traditions handed down from the time of Ptolemy onward, appropriating countless techniques and rules from various versions of Arabic, Persian, Greek, and Babylonian astrological traditions, all of which contradicted one another. In addition, he called astrologers of his own time "lazy" because they were content to work with "almanacs and ephemerides…[and] believe that a planet is at a cardinal point when it is not, or that it is not when it is," instead of observing the heavens for themselves.[67] As it was practiced in his day, Pico argued, astrology was "the most infectious of all frauds, since...it corrupts all philosophy, falsifies medicine, weakens religion, begets or strengthens superstition, encourages idolatry, destroys prudence, pollutes morality, defames heaven, and makes men unhappy, troubled and uneasy; instead of free, servile, and quite unsuccessful in

[65] See Garin, *Astrology in the Renaissance*, 77-99 and Bowden, *The Scientific Revolution in Astrology*, 33-6.
[66] Giovanni Pico della Mirandola, *Disputationes adversus astrologiam divinatoricem*, *Proem*, quoted in Tester, *A History of Western Astrology*, 209; Shumaker, *The Occult Sciences in the Renaissance*, 18-19.
[67] Pico, *Disputationes*, Book 2, Chapter 8, quoted in Shumaker, *Occult Sciences in the Renaissance*, 20. Shumaker does not give the exact word-for-word translation from the Latin here, and these words are his paraphrase of Pico's original.

nearly all their undertakings."[68] Rather than point out these errors of astrology in order to generate interest in an astrological reformation, Pico simply used these examples as reason to dismiss judicial astrology altogether.

One particular point that Pico made in the *Disputationes* that had a great effect on observational astronomy and its relationship with judicial astrology regarded the ordering of the planets.[69] Pico claimed that to be able to determine the particular influence individual planets exerted over human beings, knowledge of their proper order was paramount. He ridiculed astrologers for their inability to agree on the correct order of the planets, particularly Mercury and Venus. Pico quoted Plato, who in his *Timaeus* placed Mercury and Venus beyond the orbit of the sun in the geocentric system, as well as the thirteenth-century Arab astronomer Alpetragius, who placed Venus above the orbit of the sun while moving Mercury below.[70] Ptolemy had placed Mercury and Venus between the orbits of the moon and the sun in his geocentric system. Although Ptolemy's system was the most influential, the order of the planets was still the topic of some debate even by the late fifteenth century. In any case, Pico argued that because astronomer-astrologers

[68] Ibid., 19.
[69] Essentially all of Book 10, Chapter 4 is concerned with this question.
[70] Shumaker, *Occult Sciences in the Renaissance*, 21-27. Alpetragius is the Latin name for the Iberian Arab astronomer Nur ad-Din al Bitruji. See also Thomas Digges, *A Prognostication Everlastinge*, 110. Digges, the first Englishman to unequivocally accept the Copernican theory as both mathematically valid and a physical reality, considered this one of the major problems Copernicus solved with his publication of *De revolutionibus*. Interestingly, in the preface to his revision of his father's *Prognostication Everlastinge*, Digges had raised the similar issue of order of the planets and their distance from the earth in order to lend support to the Copernican system, which he believed had solved this problem: "…but of Venus and Mercury there hath been great controversy, because they stray not every way from the Sun as the rest do. And therefore, some have placed them above the sun, as Plato in his *Timaeus*: others beneath, as Ptolemy and the greater part of them that followed him. Alpetragius maketh Venus above the Sun and Mercury beneath, and sundry reasons have been of all sides alleged in defense of their opinions." See Chapters 2 and 3 for more information about Thomas Digges's acceptance of the Copernican theory and his relationship with astrology.

disagreed with one other about the order of the planets, they could not be trusted to understand their impact on humanity. It appears that one reader took this criticism to heart and was motivated, at least in part, to solve this conundrum—Nicolaus Copernicus.

Copernicus's formal university education began in 1491 at Jagiellonian University in Cracow, where he studied the liberal arts, including astronomy. He studied there for either three or four years, leaving sometime between 1494 and 1495 without taking his degree in order to attend the court of his uncle Lucas Watzenrode. His uncle had been recently ennobled and elevated to Bishop of Warmia, and it is possible that Copernicus expected to be installed as a canon himself.[71] For unknown reasons, Copernicus's attendance at his uncle's court was delayed, and instead, he furthered his schooling by enrolling in the University of Bologna in order to earn his doctorate. While ostensibly there to attain a doctorate in canon law, Copernicus continued his studies in astronomy and mathematics, and his time at Bologna, from 1496 to 1500, had a significant impact on his later astronomical work and informed much of his thinking about the positions and movements of the sun, moon, and planets. In Bologna, Copernicus lived with his new mentor in astronomy Domenico Maria Novara de Ferrara, the primary astronomer for the university and the most notable astrologer in the city, and Copernicus became his assistant in making astronomical observations and calculations.[72] According to Copernicus's later disciple and earliest supporter Georg Joachim Rheticus, Copernicus claimed that he was "not so much the pupil" of Novara as he was an

[71] Jack Repcheck, *Copernicus' Secret: How the Scientific Revolution Began* (New York: Simon and Schuster, 2007), 44-5.
[72] Thomas Kuhn, *The Copernican Revolution*, 129.

"assistant and witness of the observations of Domenicus Maria," and Copernicus respected Novara enough as a scientist to report that he knew his "calculations and…observations exactly."[73] It was Novara who introduced Copernicus to Pico della Mirandola's *Disputationes adversus astrologiam divinatricem*, which had been published the year that Copernicus arrived in Bologna.[74]

Although there is little to no evidence to suggest that Copernicus ever practiced astrology, it seems almost certain that he was at least aware of its operations and techniques, even if he showed no particular interest in it.[75] Novara's position as a professor of astronomy at Bologna required that he issue annual astrological predictions, typically in the form of a yearly almanac, and that he publish general predictions for favorable and ominous dates, calendars marked with the phases of the moon and important festival days, and periodic weather reports based on his reading of the heavens.[76] This was fairly typical of university astronomers in fifteenth- and sixteenth-century Italy. As Novara's assistant for three years, it is likely that Copernicus was at least exposed to the rules of its practice, and quite possible that he even aided Novara in

[73] Quoted in Repcheck, *Copernicus' Secret*, 48.
[74] Nicholas Campion, *A History of Western Astrology, Vol. 2: The Medieval and Modern Worlds* (London: Continuum Books, 2010), 107. He also introduced Copernicus to the *Epitome in Almagestum Ptolemei* of George von Peurbach and Regiomontanus, which summarized the Ptolemaic planetary system. While Copernicus would have encountered the Aristotelian-Ptolemaic system while studying both astronomy and mathematics in Cracow, he would likely have done so through the *Tractatus de sphera* of John of Sacrobosco and the *Theorica planetarum* of Campanus de Novara (no relation to Domenico Maria de Novara). While both were astronomical and mathematical textbooks in the geocentric tradition, neither contained a clear exposition of Ptolemy's original work, the *Almagest*.
[75] See Owen Gingerich, *The Book Nobody Read: Chasing the Revolutions of Nicolaus Copernicus* (New York: Penguin Books, 2004), 187-189, and 201; Alexander Koyré, *Astronomical Revolutions: Copernicus, Kepler, and Borelli* (Ithaca, NY: Cornell University Press, 1973), 94; and Kuhn, *The Copernican Revolution*, 93.
[76] Campion, *A History of Western Astrology*, 107. Campion notes that this position had existed since at least 1404.

his duties as Bologna's primary astrologer. It is certainly true that Copernicus assisted Novara in his observations of the heavens, which were accurate enough to fuel his growing doubts about the geocentric system.[77] Pico's criticism of astrologers' inability to determine the proper order of the planets apparently affected Copernicus enough that, by the time *De revolutionibus* was published over four decades later, he had devoted an entire chapter to setting their order and demonstrating it mathematically within his new heliocentric system.[78]

In Book One, Chapter Ten, of *De revolutionibus*, Copernicus argued that the simplest method to determine the order of the planets was to base it upon the amount of time they required to revolve around the sun. "We see that the ancient philosophers wished to take the order of the planets according to the magnitude of their revolutions…" Copernicus wrote, and this placed the Moon, which revolves around the earth in twenty-eight days as the closest heavenly body, and Saturn, which takes nearly thirty years to complete its cycle, as the furthest away.[79] Under the geocentric system, this meant that after the Moon, Mercury was the closest planet to the earth, then Venus, and then the sun, which appeared to take one year to return to its original position. However, Copernicus noted that Mercury and Venus never deviated from the sun more than twenty-four or forty-five angular degrees, respectively, and reasoned that if the geocentric model were

[77] Ibid.
[78] John D. North, "The Reluctant Revolutionaries: Astronomy after Copernicus," *Studia Copernicana* 13 (1975): 169-184; Robert Westman, "Proof, Poetics, and Patronage," in *Reappraisals of the Scientific Revolution* (Cambridge, 1990): 167-205; and Robert Westman, "Copernicus and the Prognosticators: The Bologna Period, 1496-1500," *Universitatis* 5 (1993): 1-5.
[79] Nicolaus Copernicus, *De revolutionibus orbium coelestium*, Book 1, Chapter 10, in *On the Shoulders of Giants: The Great Works of Physics and Astronomy*, trans. Charles Glen Wallace, ed. Stephen Hawking (Philadelphia: Running Press, 2002), 26.

true, then we should observe Venus and Mercury beyond these constraints (see figure 1 below).[80] The Ptolemaic system explained this by placing these two planets on epicycles and centering their orbits around an imaginary line that extended from the earth to the sun. Mercury and Venus then revolved around the earth on their epicycles at the same speed as the sun, thus accounting for their apparent lack of further deviation from the sun (see figure 2 below).[81] Instead, Copernicus posited that if the Sun were assumed to be at rest in the center of the cosmos and the earth were assumed to be revolving around the sun once every year, then the earth would take a position as the third planet from the sun, and the remaining planets would fall into place based on their revolutionary periods. After the sphere of the fixed stars, Copernicus positioned

> Saturn, the first of the wandering stars… it completes its circuit in 30 years. After it comes Jupiter, moving a 12 year period of revolution. Then Mars, which completes a revolution every 2 years. The place fourth in order is occupied by the annual revolution in which we said the Earth together with the orbital cycle of the Moon as an epicycle is comprehended. In the fifth place Venus, which completes its revolution in 7 ½ months. The sixth and final place is occupied by Mercury, which completes its revolution in a period of 88 days. In the center of all the rest is the sun. For who would place this lamp of a beautiful temple in another or better place than this wherefrom it can illuminate everything at the same time?[82]

While it is ultimately unknowable exactly why Copernicus developed heliocentrism when he did, it is quite possible that Pico's comprehensive criticism of astrologers' and astronomers' failure to properly order the planets spurred Copernicus to devise a new system that accounted for their apparent motion.[83]

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[80] Ibid., 28-9.
[81] Ibid., 29-30. See also Kuhn, *The Copernican Revolution*, 48-9.
[82] Ibid., 31.
[83] North, "The Reluctant Revolutionaries: Astronomy after Copernicus," 169-184; Westman, "Proof, Poetics, and Patronage," in *Reappraisals of the Scientific Revolution*, 167-205; Westman, "Copernicus and the Prognosticators," 1-5. Westman was the first to advance this theory.

De revolutionibus, of course, was finally published while Copernicus was on his deathbed in 1543. However, the first exposition of the heliocentric theory occurred nearly forty years earlier in Copernicus's *Commentariolus* of 1514, in which he outlined his theory with minimal mathematics in just forty pages.[84] This work remained unpublished and received little attention because it was meant to be circulated among his colleagues. Nevertheless, it is important to note that the origins of his theory, which finally entered public discourse following his death, can be traced all the way back to the first decade of the sixteenth century, and it is possible that Copernicus began elaborating on these ideas in private as early as 1503, just three years after he left the University of Bologna.[85] In any case, Copernicus certainly formed the concept by the time he left Italy in 1500, and his reevaluation of Ptolemy likely drew on Pico's criticism of astrology as well as his own observations of the heavens with Novara.

With the publication of *De revolutionibus*, these new ideas about the structure of the cosmos entered the scientific community of mid-sixteenth century Europe. Finally convinced by his pupil Rheticus, Copernicus consented to have his magnum opus delivered to a printer in Nuremburg, where it received an initial run of about four hundred copies.[86] From the very beginning, controversy surrounded it, but this controversy extended to very few people at first. *De revolutionibus* was prefaced with a sort of religious disclaimer by the Lutheran theologian Andreas Osiander warning that Copernicus's hypotheses "need not be true or even probable" because mathematicians

[84] Koyré, *Astronomical Revolutions: Copernicus, Kepler, and Borelli*, 18-28.
[85] Gingerich, *The Book Nobody Read*, 32.
[86] Ibid., 128.

"will adopt whatever suppositions enable the motions [of the planets] to be computed correctly from the principles of geometry." [87] Osiander included this without either Copernicus's or Rheticus's knowledge. It is possible that Osiander wrote this foreword to preempt any criticism from religious figures that heliocentrism contradicted scripture, but it is just as likely that he included it in anticipation of the reaction of other mathematicians and astronomers, whose Ptolemaic-Aristotelian cosmos was deeply shaken by this work.

In *De revolutionibus* Copernicus explained heliocentrism in extremely technical language with the addition of highly advanced mathematics that would have been comprehensible only to other astronomers, mathematicians, and astrologers.[88] In a sense, the specialized nature of the knowledge Copernicus presented forestalled any substantial negative reaction on the part of the public until decades later, and then, only once its ideas had penetrated popular consciousness. Understanding the process of this dissemination of knowledge across England, which contained one of the most receptive scientific audiences, is crucial to understanding the impact of Copernicanism on judicial astrology in the early modern courts of the Tudors and the Stuarts.

[87] Andreas Osiander, foreword, in Nicolaus Copernicus, *De revolutionibus orbium coelestium*, 7.
[88] Kuhn, *The Copernican Revolution*, 185.

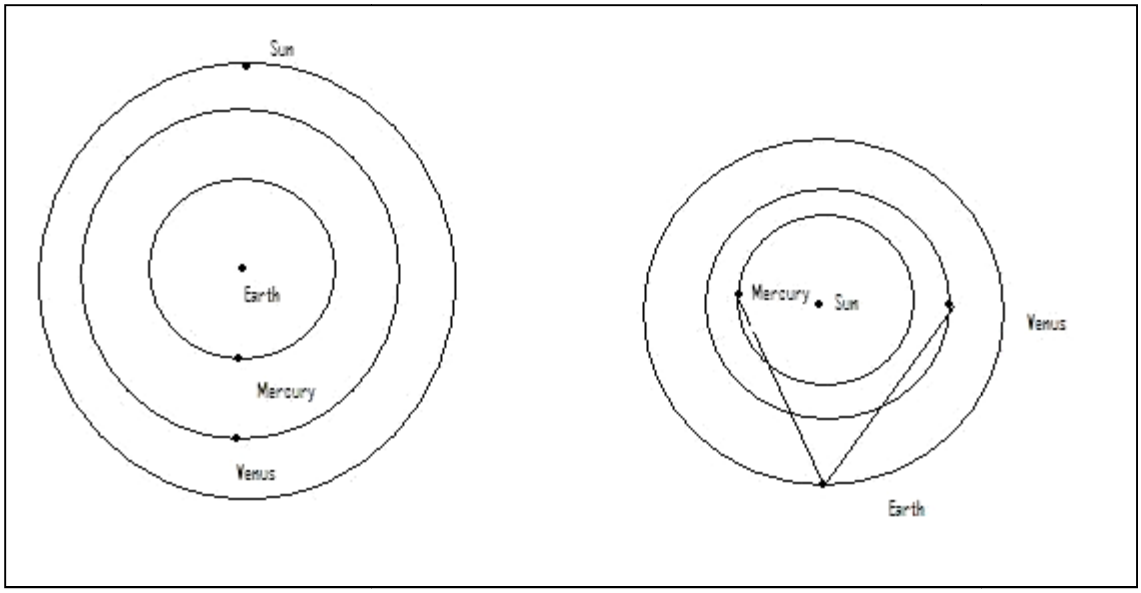

Figure 1. In the Ptolemaic system, it should be possible to view Mercury and Venus at 180° opposite the sun at their perigees (left). Since they never deviate more than 24° and 45°, respectively, Copernicus argued against the Ptolemaic cosmos and order of the planets. In the Copernican system, the angular distances corresponded to maximum possible distances away from the sun that either Mercury or Venus could achieve as observed from the earth (right). Based on their orbital period—Mercury's 88 days and Venus's 224 days—Copernicus placed Mercury closer to the sun in his heliocentric system.

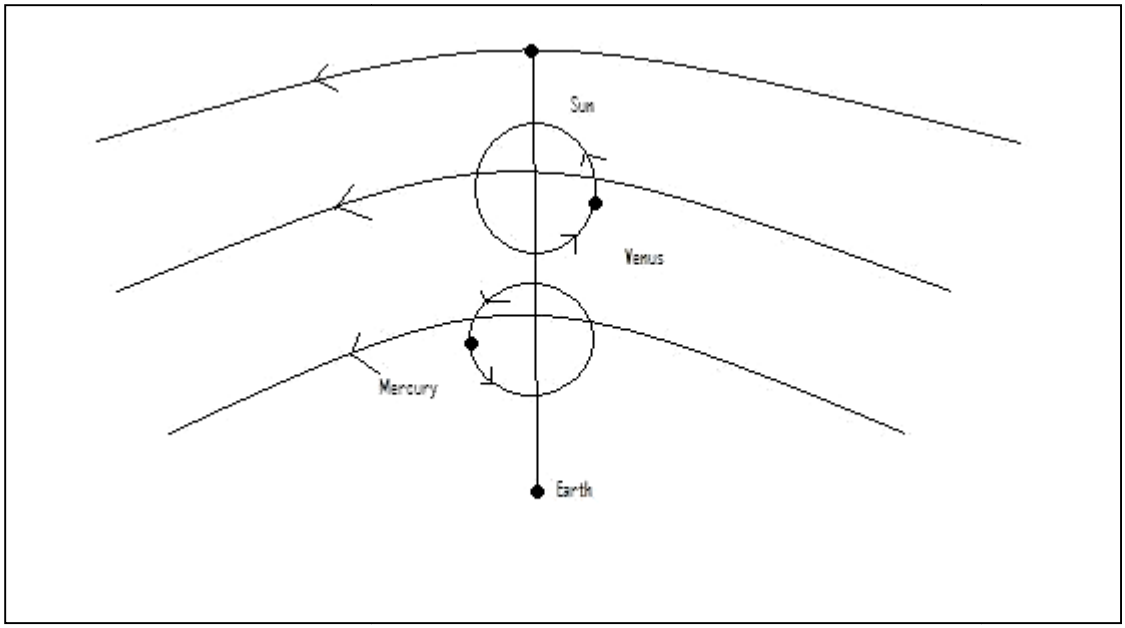

Figure2. Ptolemy's geocentric system explained the lack of apparent deviation for Mercury and Venus by positioning these planets on epicycles and centering their orbits around an imaginary line that extended from the earth to the sun. Mercury and Venus then revolved around the earth on their epicycles at the same speed as the sun, accounting for their perceived closeness to the sun. Copernicus rejected this explanation.

CHAPTER TWO

COPERNICANS, SEMI-COPERNICANS, AND MATHEMATICAL COPERNICANS: THE ENGLISH REACTION TO HELIOCENTRISM

By modern standards, the process of disseminating Copernicanism across the scientific community of Europe was achingly slow. Remarkably few Copernicans existed between the publication of *De revolutionibus* in 1543 and Galileo's telescopic observations of the heavens in the 1609 and 1610. However, though few accepted the physical reality of heliocentrism until after Galileo, more accepted its mathematics without question. This was a fairly typical position among astronomers and astrologers who adopted the Copernican system slowly and often incrementally between the 1570s and Galileo's telescopic observations in 1609.[89] How does one define a Copernican? If we define a Copernican only as one who definitively accepted the new sun-centered system as a physical reality, then only ten existed from the publication of *De revolutionibus* in 1543 to the turn of the seventeenth century.[90] However, while only a few astronomers and astrologers fully adopted the Copernican system in place of the Ptolemaic, many "semi-Copernicans" accepted heliocentrism as mathematically superior to the Ptolemaic-Aristotelian system and denied or remained neutral as to its physical

[89] Kuhn, *The Copernican Revolution*, 186.

[90] Robert Westman, "The Copernicans and the Churches," in *God and Nature: Historical Essays on the Encounter between Christianity and Science*, ed. David C. Lindberg and Ronald L. Numbers (Berkley: University of California Press, 1986), 85, and Robert Westman, "The Astronomer's Role in the Sixteenth Century: A Preliminary Study," *History of Science*, Vol. 28 (1980): 105-47. Westman counted Georg Joachim Rheticus, Michael Maestlin, Christopher Rothmann, Johannes Kepler, Galileo Galilei, Giordano Bruno, Thomas Digges, Thomas Harriot, Diego de Zuñiga, and Simon Stevin as the only definitive Copernicans who accepted heliocentrism as a physical reality between 1543 and 1610.

validity. In short, there was a wide variety of receptions of Copernicanism often shaped by practical, mathematical concerns.

Before examining changes in astrological practice, it will be useful to track the introduction of the Copernican theory into England in the mid-sixteenth century. Though England remained somewhat intellectually isolated from continental Europe, many English scholars attended European universities and ideas that circulated in the schools of Europe soon found their way across the Channel. Like the continental system, the university system in England incorporated some scientific studies—mainly physics and mathematics—but its primary concern was Latin grammar in the earlier levels and theology and law in the later stages.[91] But by the time of Copernicus's publication of *De revolutionibus*, the royal and noble courts, not the universities, had become the center of the most dynamic scientific activity in England.[92] It was within this cultural and institutional milieu that the heliocentric theory began to take root.

The first reference to Copernicus in England, thirteen years after the publication of *De revolutionibus*, illustrates this larger setting. In his *Castle of Knowledge* (1556), an elementary arithmetic textbook, the eminent English mathematician Robert Recorde briefly considered the question concerning the "quietnes of the earth" and whether or not "it chaunceth, that the opinion most generally receiued is not moste true."[93] Recorde

[91] William T. Costello, *The Scholastic Curriculum at Early Seventeenth Century Cambridge* (Cambridge: Harvard University Press, 1958), 70; John L. Russell, "The Copernican System in Great Britain," in *The Reception of Copernicus' Heliocentric Theory*, ed. Jerzy Dobrzycki (Dordrecht: Reidel, 1973), 189.
[92] Pumfrey and Dawbarn, "Science and Patronage in England," 141; Robert Westman, "The Astronomer's Role in the Sixteenth Century: A Preliminary Study," *History of Science*, Vol. 28 (1980): 105-47.
[93] Robert Recorde, *The Caste of Knowledge* (London, 1556), 164.
http://eebo.chadwyck.com.echo.louisville.edu/search/full_rec?SOURCE=pgimages.cfg&ACTION=ByID&ID=99850880&FILE=../session/1303965549_5839&SEARCHSCREEN=CITATIONS&VID=16115&PA

attended Oxford in the early 1530s, earned his bachelor's degree there in 1531, and was elected to All Soul's College later that year to study medicine. Though he obtained a license to practice medicine in 1533, it appears that Recorde moved to Oxford to acquire a doctorate of medicine in the early 1540s. There is no substantial evidence to prove that he taught mathematics while there, but most of his later scholarly works in mathematics bore the mark of a man who had gained a pedagogical mastery of the subject.

Recorde was among the first generation of scholars who began writing in English for the practical benefit of the increasingly literate merchant class, and *The Castle of Knowledge* served as a primer for basic Ptolemaic astronomy and arithmetical and geometrical astronomy.[94] While Latin remained the lingua franca of most scholarly texts, the English vernacular witnessed an increase in use due, in part, to the demand for beginners' texts covering practical knowledge like Recorde's *Castle of Knowledge*.[95] As in many of his other works, Recorde composed *The Castle of Knowledge* as a dialogue

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GENO=91&ZOOM=FIT&VIEWPORT=&SEARCHCONFIG=var_spell.cfg&DISPLAY=AUTHOR&HIGHLIGHT_KEYWORD=undefined. (Accessed 28 April 2011). All following citations of Recorde's work come from the Early English Books Online database of the Henry E. Huntington Library.

[94] Christopher Hill, *The Intellectual Origins of the English Revolution Revisited* (London: Oxford University Press, 1997), 8 and 78; Francis R. Johnson, *Astronomical Thought in Renaissance England: A Study of English Scientific Writings, 1500-1645* (Baltimore: John Hopkins University Press, 1937), 10-12 and 76; Tester, *History of Western Astrology*, 224-5.

[95] See Katherine Hill, "Juglers or Schollers?: Negotiating the Role of a Mathematical Practitioner," *The British Journal for the History of Science*, Vol. 31, No. 3 (1998): 254-5 and J. Peter Zetterberg, "The Mistaking of 'the Mathematicks' for Magic in Tudor and Stuart England," *The Sixteenth Century Journal* Vol. 11, No. 1 (1980): 86. From the early 1540s until his death in 1558, Recorde published several very popular works on mathematics, all in English, and all designed as teaching tools for novice mathematics students: an arithmetic textbook *The Grounde of Artes* (1543), a translation and commentary on Euclid in *A Pathway to Knowledg* (1551), and *The Whetstone of Witte* (1557) on basic algebra and number theory. Recorde's pioneering introduction of mathematics to the English masses may have been specifically designed to remove the magical quality of numbers that pervaded mathematical discourse in the mid-sixteenth century. In general, Recorde rejected the more esoteric notions of some of his contemporaries regarding the divine power of the stars and mystical power of numbers. While he attempted to purge numbers of their more "wonderful" and "mysterious" qualities, Recorde maintained the Neoplatonic notion of numbers as the key to unlocking the secrets of nature. However, it was the preoccupation with the practical that typified much of his work in mathematics.

between a master and a student. The master first claims that he "neede not to spende anye tyme in proouing" the immobility and centrality of the earth since "that opinion is so firmelye fixed in most mennes headdes, that they accompt it mere madnes to bring the question in doubt."[96] However, to demonstrate that the geocentric model was not as impervious to criticism as a neophyte mathematics student might assume, Recorde's master invoked several ancient authorities who argued against it, including "not only Eraclides, Ponticus, a great Philosopher, and two great clerkes of the Pythagoras schole, Philolaus and Ecphantus…but also Nicias Syracusius, and Aristarchus Samius, [who] seem with strong arguments to approoue" the heliocentric theory.[97] The appeal to ancient authority was, of course, a common technique among early modern writers who desired to imbue their work with scholarly credibility, and Recorde included Copernicus as the last in a line of natural philosophers, describing him as "a man of greate learning, of muche experience, and of wondrefull diligence in obseruation," who "renewed the opinion of Aristarchus Samius, and affirmeth that the earthe not only moveth circularly about his owne centre, but also may be, and yea is, continually out of the precise centre of the world…"[98]

Despite his concision, Recorde treated the heliocentric cosmos as a valid alternative, and the brevity of the allusion can be attributed to the rudimentary nature of the textbook. Understanding the implications of the theory and the anticipated reception among skeptical contemporary scholars, the student in Recorde's dialogue reacted

[96] Recorde, *The Castle of Knowledge*, 164.
[97] Ibid.
[98] Ibid.

incredulously: “Nay syr in good faith, I desire not to heare such vaine phantasies, so farre againste common reason, and repugnante to the consente of all the learned multitude of Wryters, and therefore let it pass forever, and a day longer,” to which the master replied,

> You are too yonge to be a good iudge in so great a matter: it passeth farre from your learninge, and theirs also that are muche better learned than you, to improue his supposition by good arguments, and therefore you are best to condemne nothing that you do not well vnderstand but another time, as I sayd, I will so declare his supposition, that you shall not only wonder to hear it, but also peraduenture be as earnest then to credite it, as you are to condemne it.”[99]

This caveat against condemning a hypothesis before one fully understands its particulars implies that Recorde was well aware that the last word on Copernicus had not yet been written. In this spirit, Recorde claimed that “the reasons” for Copernicus’s theory “are too difficult for this Introduction,” and so he “omit[ted] them for another time…because the understanding of that controversy dependeth on profounder knowledge than in this Introduction may be uttered conveniently….”[100] Unfortunately, Recorde died two years later without expounding upon Copernicus again.

The next mention of Copernicus in England came later in 1556 in John Dee’s preface to John Feild’s *Ephemeris*. John Dee, often described as a magus, truly deserves the appellation “Renaissance man.” During his lifetime, he was involved in nearly all major intellectual pursuits within the domain of natural philosophy, including astrology. Showing great promise as a young grammar school student, Dee eventually attended St. John’s College, Cambridge, and Louvain University in Flanders where he studied under the prominent mathematicians Gemma Frisius and Gerard Mercator from 1548 to

[99] Ibid. Recorde’s “Master” admonishes his “Scholar” in this way throughout the text.
[100] Ibid.

1550.[101] It is possible that he first became acquainted with the theory of Copernicus via Frisius while at Louvain. In any case, after lecturing on mathematics in France for a year, he returned to England in 1551 and began serving first in the court of the Earl of Pembroke and then the Duke of Northumberland.[102]

The acquaintanceship between John Dee and John Feild evidently began while both were serving prison terms. Dee, a partisan of the future Queen Elizabeth I, had been imprisoned along with Feild in 1555 for their alleged astrological prognostication of the fate of Queen Mary. Dee's charge was for the "lewde and vayne practices of calculing and conjuring," which was considered more serious during Mary's reign than it would be accounted later in the Elizabethan era.[103] Following her ascension to the throne, Queen Mary feared the use of prophecy, which often accompanied rumors of rebellion. Several predictions concerning Mary's death circled about London in 1554, and it seems that she took no chances with Dee or Feild.[104] While imprisoned, Dee suggested that Feild model his new planetary tables on the Prutenic tables, which were based on the observations and calculations of Copernicus. Feild agreed and enlisted Dee to write the preface to his work.

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[101] Peter French, *John Dee: The World of an Elizabethan Magus* (London: Routledge and Kegan Paul, 1972), 4-25.
[102] Ibid., 40-62.
[103] J. Peter Zetterberg. "Hermetic Geocentricity: John Dee's Celestial Egg." *Isis* Vol. 70, No. 3 (1979): 386 n.6. See also Keith Thomas, *Religion and the Decline of Magic*, 404 and 421; French, *John Dee*, 6. Thomas alleges that Queen Elizabeth's policies against astrologers, magicians, conjurers, and others involved in occult subjects were just as harsh as her predecessors, yet as her reign became more established, the severity lessened. Like many other rulers, Queen Elizabeth I seems to have treated those who made predictions differently depending on whether those predictions were favorable or unfavorable. French simply claims that Dee was falsely accused.
[104] Thomas, *Religion and the Decline of Magic*, 404.

Feild's *Ephemeris* was an English version of the Prutenic tables, themselves based on Copernicus's heliocentric model. The original Prutenic tables had been published by Erasmus Reinhold five years earlier in 1551, but they specified the location of the stars and planets at given times based on the location of Prussia. Feild's *Ephemeris* used the same data to recalculate the tables based on the position of the stars relative to London time.[105] Dee was described by a contemporary as "a most ardent defender of the new hypothesis and Ptolemaic doctrine."[106] His views on the physical reality of heliocentrism remain enigmatic. On the one hand, every mention of the theory in his writings is positive. On the other hand, he described the cosmos in Aristotelian and Ptolemaic terms at length in his later works, the *Propaedeumata aphoristica* and the *Monas hieroglyphica*.[107] At the very least, it seems that Dee, like many of his mathematically knowledgeable contemporaries, recognized the advantages that the Copernican theory

[105] Owen Gingerich, "The Role of Erasmus Reinhold and the Prutenic Tables in the Dissemination of Copernican Theory," *Studia Copernicana* 6 (1973), 43-62. See also Owen Gingerich, *The Book Nobody Read: Chasing, passim.*

[106] Richard Forster, *Ephemerides meteorographicae ad annum 1575* (London, 1575), 67 [unpaginated]. http://eebo.chadwyck.com.echo.louisville.edu/search/full_rec?EeboId=99851234&ACTION=ByID&SOURCE=pgimages.cfg&ID=99851234&FILE=..%2Fsession%2F1303966541_8301&SEARCHSCREEN=CITATIONS&VID=16502&PAGENO=34&ZOOM=100&VIEWPORT=&CENTREPOS=&GOTOPAGENO=34&ZOOMLIST=100&ZOOMTEXTBOX=&SEARCHCONFIG=var_spell.cfg&DISPLAY=AUTHOR. (Accessed 28 April 2011). *"…Iohannem Dee, nouarum hypothesium, & Ptolemaicae dotrinae acerrimum vindicem."* See also Russell, "The Copernican System in Great Britain," 197. The translation is adapted from Russell. He suggests that Forster's differentiation between "hypothesis" and "doctrine" was meant to underscore the physical reality of the Ptolemaic system while highlighting the mathematical usefulness of the Copernican.

[107] Russell, "The Copernican System in Great Britain," 191; Bowden, *The Scientific Revolution in Astrology*, 62-68; Stephen Johnston, "Like Father, Like Son? John Dee, Thomas Digges, and the Identity of the Mathematician," in *John Dee: Interdisciplinary Studies in English Renaissance Thought*, edited by John Clucas (Dordrecht: Springer, 2006), 74.

provided for calculating the positions of the planets while perhaps not accepting it as a physical or metaphysical reality.[108]

In his preface to Feild's *Ephemeris*, Dee was clearly more concerned with the mathematical precision of Copernicus than with the physical basis of his claims.[109] He extolled the "more than Herculean efforts" of Copernicus to "restore the heavenly discipline" to its proper stature following the steady accretion of errors since the time of Ptolemy. However, after praising his "radiant brilliance" and "divine studies," Dee contended that the preface to Feild's work was not the proper place to discuss the import of such a hypothesis.[110] Given the limited space at his disposal, Dee may merely have meant that a longer work would be necessary to discuss heliocentrism more fruitfully, but his commendation of Copernicus in the preface of a work on planetary tables suggests that the context of his praise, in this instance, was mathematical rather than physical. This conscious differentiation is, in one sense, curious for Dee since his Hermetic, Neoplatonic, and occult dispositions remained fully integrated with mathematical,

[108] Russell, "The Copernican System in Great Britain," 197. Throughout his treatment of the heliocentric theory in England, Russell's criteria for the acceptance of the Copernican theory remain rather loose. Russell defines as Copernican any scholar who looked favorably upon Copernican mathematics. Therefore, many late sixteenth- and early seventeenth-century figures who were noncommittal about the physical reality of heliocentrism—such as Dee—are regarded as Copernicans by Russell.

[109] Russell, "The Copernican System in Great Britain," 191.

[110] John Dee, preface to John Feild, *Ephemeris anni 1557 currentis iuxta Copernici et Rheinhaldi canones* (London, 1556), sig. Ai*r*. http://eebo.chadwyck.com.echo.louisville.edu/search/full_rec?SOURCE=pgimages.cfg&ACTION=ByID&ID=99847806&FILE=../session/1303967079_9359&SEARCHSCREEN=CITATIONS&VID=12867&PAGENO=2&ZOOM=FIT&VIEWPORT=&SEARCHCONFIG=var_spell.cfg&DISPLAY=AUTHOR&HIGHLIGHT_KEYWORD=param%28HIGHLIGHT_KEYWORD%29. (accessed 28 April 2011). The following citations for Feild's *Ephemeris* also come from this site. "*Sperabam etiam alios, illos praesertim qui in Astronomicis tum multa, tum magna tractant, et moliuntur, de COPERNICI, aut Rhetici & Reinhaldi scriptis… Illius quidem, ob labors plus quam Heruleos, in coelesti disciplina restauranda, eademque firmissimis rationum momentis, corroboranda, ab eodem exantlatos: (cuius hypothesibus nunc non est disserendi locus).*" Translation adapted from Stephen Johnston and Peter French. See Johnston, "Like Father, Like Son? John Dee, Thomas Digges, and the Identity of the Mathematician," 75; and French, *John Dee*, 98-9.

astronomical, and empirical modes of thinking throughout his life.[111] However, while Dee regarded mathematics highly, he saw them merely as a means, and a subservient one at that, to philosophical truth. For Dee, astronomical mathematics was but one of many paths to knowledge about natural philosophy, and when it contradicted deeper truths about the nature of the cosmos derived from ancient Hermetic texts, Dee accorded mathematics a status secondary to the metaphysical.[112]

Feild, on the other hand, may not have separated his cosmological philosophy from his mathematical understanding of the cosmos.[113] Feild's reference to Copernicus is even briefer than Dee's, though his adulation is no less glowing. He asserted that his planetary tables were constructed "following the authority" of both Copernicus and Reinhold "whose solid writings are founded on true, certain, and sincere demonstrations."[114] However, while Feild used the Copernican system and the tables of Reinhold to calculate the positions of the planets, he wrote no other work accepting the heliocentric theory, and it is unclear from his writings whether by "demonstrations" he meant mathematical or observational since both could be employed for the construction of tables. Given his consultation of Reinhold's tables, however, it seems likely that Feild

[111] French, *John Dee*, 2-3.
[112] Johnston, "Like Father, Like Son? John Dee, Thomas Digges, and the Identity of the Mathematician," 74; Frances Yates, *Giordano Bruno and the Hermetic Tradition* (Chicago: Chicago University Press, 1964), 148-150.
[113] Russell, "The Copernican System in Great Britain," 192. Russell claimed that Feild accepted the Copernican theory "without qualification," and he points to Feild's own preface in support of both his acceptance of the mathematical model and its theoretical underpinnings. See also Johnson, *Astronomical Thought in Renaissance England*, 134-5.
[114] John Feild, *Ephemeris anni 1557 currentis iuxta Copernici et Rheinhaldi canones*, sig. Aiiir. *"…in ea authores sequuntus N. Copernicum et Erasmum Reinholdum, quorum scripta stabilita sunt et fundata veris, certis et sinceris demonstrationibus."*

referred to Copernican mathematics. In either case, the uses of the strong words "true [and] certain" exhibit clear approval of Copernicus.

The first English scholar to unquestionably adopt the Copernican theory as a physical reality and to substitute it for the Ptolemaic system was Thomas Digges. Digges received no formal university education, but his father, the respected mathematician Leonard Digges, personally instructed him in mathematics and astronomy when he was child. In 1554, when Thomas was only eight years old, Leonard Digges participated in Thomas Wyatt's unsuccessful rebellion against the newly crowned Queen Mary and was sentenced to death for his role in the insurrection. Though he avoided execution, his property was confiscated and he spent five years attempting to regain his estates before dying a poor man in 1559. The guardianship of Thomas passed to John Dee who acted both as his surrogate father and mathematics mentor until Digges reached adulthood five years later.[115] Under Dee's tutelage, Digges flourished as one of the best English mathematicians of the 1570s and 1580s.

During these decades, several celestial events turned the eyes of England's astronomers and astrologers to the heavens, and Digges's careful observations of these events led him to rely on the Copernican system as essential to interpreting their positions and motions. The first event was a supernova that appeared in the sky in early November in 1572. Digges believed that by measuring the parallax of the new supernova, he could determine whether the earth or the sphere of the fixed stars rotated once a day. In a short treatise on the nova, *Alae seu scalae mathematica*, published early the next year, Digges

[115] Johnston, "Like Father, Like Son? John Dee, Thomas Digges, and the Identity of the Mathematician," 65-84 and Johnson, *Astronomical Thought in Renaissance England*, 131 and 161-210.

wrote that the new star offered an opportunity "for proving whether the motion of the earth set forth in the Copernican theory is the sole reason why this star is apparently diminishing in magnitude; for if it were thus always decreasing toward the spring equinox, it would be observed to be very small in its own magnitude." By this method, Digges continued,

> it would not be at all difficult if this remarkable Phenomenon [the supernova] should persist for a long time, to discern by exact judgment whether the earth lies quiet and immoveable in the center of the World, and whether that huge mass of moving and fixed Orbs rotates in a circle by a most rapid course in the space of 24 hours, or rather, that that immense sphere of fixed stars remains truly fixed and that apparent motions occurs only from the circular rotation of the Earth with reference to the celestial poles themselves. [116]

Digges's observational experiment was subjected to great criticism by Tycho Brahe in his *Astronomiae Instauratae Progymnasmata*. Brahe argued that Digges only took into account the diurnal motion of the earth and not its annual motion about the sun in his calculations. Furthermore, a high degree of parallax would have placed the supernova close to the earth; the fact that this was not observed placed it far beyond the orbit of Saturn. Brahe asserted that if Copernicus was right, the supernova would be much too far away from the earth for its location and apparent magnitude to be affected by the earth's

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[116] Thomas Digges, *Alae seu scalae mathematica* (London, 1573), sig. A3*v*. http://eebo.chadwyck.com.echo.louisville.edu/search/full_rec?SOURCE=pgimages.cfg&ACTION=ByID&ID=99845343&FILE=../session/1303967407_10068&SEARCHSCREEN=CITATIONS&VID=10236&PAGENO=7&ZOOM=100&VIEWPORT=&SEARCHCONFIG=var_spell.cfg&DISPLAY=AUTHOR&HIGHLIGHT_KEYWORD=undefined. (accessed 28 April 2011). *"…et occasionem maxime opportunam experiendi an Terrae motus in Copernici Theoricis suppositus, sola cuasa fiet cur haec stella magnitudine apparent miniatur, nam si ita fuerit in Aequinoctio verno simper decrescens minima sua magnitudine conspiceretur…et hac ratione haud difficile esset si diu presueraverit Phoenomenon istud mirabile, exacto iudicio discerne an Terra immobilis in Mundi centro quiescat, et ingens illa Orbium erraticarum et fixarum moles rapidissimo cursa 24 horarum spacium in gyrum rotetur, seu potius fixarum illa imensa sphaera vera fixa maneat, et apparens ille motus tantummodo ex Terrae circulari super Polis suis rotatione contingat."* Translation by Francis R. Johnson. See Johnson, *Astronomical Thought in Renaissance England*, 158-159; and Russell, "The Copernican System in Great Britain," 192-193.

position. While Digges seems not to have realized that the diurnal parallax would have appeared the same relative to his position on the earth whether the earth moved against a backdrop of stationary stars or whether the firmament wheeled about an immobile and centrally located earth, his adherence to observation as the arbiter of knowledge about the Copernican theory shows that he was concerned with detailed collection of data. Moreover, Digges intended to use this data not merely to better calculate the positions of the planets but to describe the physical nature of the cosmos.[117]

The second celestial event to cause astronomers and astrologers to question the conventional wisdom regarding Ptolemaic mathematics and the Ptolemaic-Aristotelian cosmological structure was the Great Comet of 1577, which was observed and recorded by numerous astronomers across Europe including not only Thomas Digges, but also Michael Maestlin and Tycho Brahe.[118] Unlike the supernova of 1572, which in reality was much too far away for any discernible parallax, the comet's close approach to the earth allowed the most keen observers of celestial phenomena to determine within a reasonable degree of precision the comet's distance from the earth. The consensus among those who had begun to doubt the efficacy of the Ptolemaic-Aristotelian cosmos was that it was impossible for the comet to lie below the sphere of the moon, as all Aristotelians accepted.[119] Aristotelians believed in the incorruptibility of cosmos beyond the moon's

[117] See *The Reception of Copernicus' Heliocentric Theory*, ed. Jerzy Dobrzycki (Dordrecht, Netherlands: D. Reidel Publishing Company, 1972), especially Russell, "The Copernican System in Great Britain," 193; Robert S. Westman, "The Comet and the Cosmos: Kepler, Mästlin, and the Copernican Hypothesis," 18-20, 24 and 25; and Kristian P. Moesgaard, "The Influence of Copernicus on Tycho Brahe," 31-56.
[118] Westman, "The Comet and the Cosmos," 10 and 28.
[119] Ibid., 8-9.

orbit and had attributed all observable change in the heavens to have taken place below the sphere of the moon.[120]

As several observers noticed, however, if the comet were below the orbit of the moon, it would have a high degree of parallax when in fact none was observed. For example, Johannes Kepler, who was only six years old at the time of the comet, wrote much later in his *Mysterium Cosmographicum* (1595) that his tutor Maestlin "showed me a…reason [in support of Copernicus] by another special argument: he found that the Comet of the year '77 moved constantly with respect to the motion of Venus professed by Copernicus; and he conjectured from this superlunary height that [the Comet] completed its orbit in the same orb as the Copernican Venus," clearly placing it beyond the sphere of the moon.[121] Similarly, in his treatise on the use of the astrolabe *Astrolabium vranicum generale* (1596), John Blagrave wrote that "our late learned countryman, Master Digges is his Scala Mathematica found, because he had no Parallax, that the [comet] must needes be beyond the Spheere of the ☽."[122] Although this

[120] For a concise summary of the nature of the Aristotelian cosmos, see David C. Lindberg, *Beginnings of Western Science*, 245-280.

[121] Johannes Kepler, *Gesammelte Werke*, Vol. I, ed. Max Caspar (Munich, 1938), 16: 39-40 and 17: 1-10, quoted in Westman, "The Comet and the Cosmos," 8. "*…tanem alia quadam peculiari ratione tertiam mihi causam praebuit ita sentiendi: dum Cometam anni 77 deprehendit, constantissime ad motum Veneris a Copernico proditum moeri, et capta ex altitudine superlunari coniectura , in ipso orbe Venerio Copernicano curriculum suum absoluere.*" The translation is Westman's. Westman later notes that Kepler later came to the conclusion, much like Tycho Brahe's criticism of Digges's use of the diurnal parallax of a supernova to argue in favor of Copernicanism, that mathematically, the movement of this comet could be accounted for in either the Ptolemaic or Copernican systems. What its observation *did* demolish was the idea that the heavens above the moon were necessarily perfect and unchangeable and that the planets were carried about by crystalline sphere, since the comet would be required to pass through them.

[122] John Blagrave, *Astrolabium vranicum generale* (London, 1596), [unpaginated] 33. http://eebo.chadwyck.com.echo.louisville.edu/search/full_rec?SOURCE=pgimages.cfg&ACTION=ByID&ID=99840340&FILE=../session/1303967962_11286&SEARCHSCREEN=CITATIONS&VID=4837&PAGENO=16&ZOOM=75&VIEWPORT=&SEARCHCONFIG=var_spell.cfg&DISPLAY=AUTHOR&HIGHLIGHT_KEYWORD=undefined. (accessed 28 April 2011).

observation itself did not deliver a mortal blow to Ptolemaic-Aristotelian cosmology, it *did* demolish the idea that the heavens above the moon were necessarily perfect and unchangeable and that the planets were carried about by crystalline spheres, since the comet would be required to pass through them. At the very least, it offered more ammunition to those who believed that the Ptolemaic system required more than merely revision.

Thomas Digges's *Alae seu scalae mathematica* was written in Latin and addressed to an international audience, but his next exposition of the Copernican theory three years later was intended for the English masses. Beginning in 1553, Digges's father published an almanac entitled *A Prognostication Everlastinge of Right Goode Effecte*, which contained information on weather prediction and the positions of the stars and planets. Leonard Digges published two more editions in 1554 and 1556 before his premature death at age 39 in 1559. Thomas Digges began publishing a revised version in 1576, in which he used Copernican "geometricall demonstrantion[s]" to correct the errors that had accumulated in his father's calculations to show "a perfit description of the caelestiall orbes according to the most auncient doctrine of the Pythagoreans, lately revived by Copernicus."[123] Even though he thought of heliocentrism as a physical reality,

[123] Thomas Digges, *A Prognostication Everlastinge of Right Goode Effecte* (London: Thomas Marsh, 1576), sig. N1*r*. Digges's appeal to Pythagoras as an ancient proponent of heliocentrism is based on his misunderstanding of Pythagoras's actual belief that *both* the sun and the earth revolved around a "central fire," which he imagined as the "soul of the universe". See, for example, Philip Wheelwright, ed., *The Presocratics* (New York: MacMillan Publishing, 1966), 200-235; Giorgio de Santillana, *The Origins of Scientific Thought: From Anaximander to Proclus* (Chicago: University of Chicago Press, 1961), 53-78; Thomas Africa, "Copernicus's Relation to Aristarchus and Pythagoras," *Isis* Vol. 52, No. 3 (1961): 403-409; and most recently, James Hannam, *God's Philosophers: How the Medieval World Laid the Foundations of Modern Science* (London: Icon Books, 2010). For information regarding the publication of Digges's almanac, see Christopher Hill, *Intellectual Origins of the English Revolution Revisited*, 46. Thomas Digges's edition of his father's work would go on to be published annually until 1635.

Digges still appealed to Copernicus's mathematical demonstrations in order to make his case:

> But in this age, one rare wit (seeing the continual errors that from time to time more & more have been discovered, besides the infinite absurdities in their Theorickes, which they have been forced to admit that would not confess mobility in the ball of the earth) hath by long study, painful practice, and rare invention delivered a new Theoricke or model of the world, shewing that the earth resteth not in the Center of the whole world…[124]

Digges viewed the constant, miniscule mathematical adjustments made by those attempting to preserve the Ptolemaic model as "absurd" and concluded that that entire enterprise was misguided.

Furthermore, in Digges's philosophy, fixity implied a certain degree of nobility, and the motion of the earth relegated it to what he regarded as its rightful place as a location of sin and degradation. By moving the earth from its central location, Digges dethroned the earth, so to speak, and the ignobility and baseness of the earth was revealed by its reduced importance as a planet that orbited

> only in the Center of this our mortal world or Globe of elements, which environed and enclosed in the Moon's Orb, and together with the whole globe of mortality is carried yearly round about the Sun…[and] in respect of the immensity of that immovable heaven, we may easily consider what little portion of God's frame our Elementary corruptible world is, but never sufficiently be able to admire the immensity of the Rest.[125]

Digges envisioned the cosmos as an infinite kingdom, in which the sun ruled "like a king in the middest of all" from the center of the solar system, which was its own "Celestiall

[124] Digges, *A Prognostication Everlastinge*, sig. M1*r*.
[125] Ibid., sig. M1*r*-M2*r*.

temple."[126] The idea of the sun in a central position of authority better harmonized with the metaphysical cosmos as Digges understood it.

Finally, though his arguments rested mostly on mathematical demonstrations, Digges specifically rejected the notion that the Copernican theory was merely a mathematical hypothesis designed to "save the phenomenon" of perfectly circular orbits. Digges forcefully asserted that Copernicus "meant not, as some have fondly excused him, to deliver these grounds on the earth's mobility only as Mathematical principles, feigned & not as Philosophical truly averred" but rather intended his theory to represent a physical reality.[127] Indeed, he had written in the marginalia on the title page of his own copy of Copernicus's *De Revolutionibus* that "the common opinion errs."[128]

After Digges's unequivocal exposition of the Copernican theory, the astronomical, astrological, and mathematical writers of the last quarter of the sixteenth century typically took note of heliocentrism in their works regardless of whether they accepted or rejected it. Certainly by the 1570s, it had become notable enough within these circles to require some comment. For example, Thomas Blundeville, a well-respected mathematician, logician, and Christian humanist was among the first in England to argue against the Copernican theory on theological grounds, but he couched this within larger arguments about its scientific legitimacy. Still, as an accomplished mathematician, Blundeville recognized the computational advantages to the Copernican theory and only cautioned his readers not to confuse mathematical simplification with physical reality. In

[126] Ibid.
[127] Ibid.
[128] Quoted in Gingerich, *The Book Nobody Read*, 119-120. The phrase, written in Latin, reads "*Vulgi opinio error.*"

his *Exercises* of 1594, an eclectic mixture of introductory material on arithmetic, navigation, cartography, and the use of the astrolabe, Blundeville wrote of heliocentrism that

> some also deny that the earth is in the middest of the world, and some affirme that it is mouable, as also Copernicus by way of supposition, and not for that he thought so in deede: who affirmeth that the earth turneth about, and that the sunne standeth still in the midst of the heauens, by help of which false superstition he hath made truer demonstrations of the motions and reuolutions of the celestiall Spheares than euer were made before as plainly appeareth in his booke *de Reuolutionibus* dedicated to *Paulus Tertias* the pope, in the year of our Lord 1536.[129]

Despite deriving more precise mathematical positions for the planets from what he considered a superstitious physical hypothesis, Blundeville understood the importance of its mathematical implications. Like many of his contemporaries, Blundeville approached Copernicanism cautiously and accepted it piecemeal—appropriating the less controversial aspects while denying others.

Unlike Digges, Blundeville refused to entertain the idea that the earth actually moved and was most adamant in this respect, deferring to both the authority of classical philosophers as well as scripture:

> But Ptolemie, Aristotle, and all the other olde writers affirm the earth to be in the middest and to remain imooueable and to be in the very Center of the world, proouing the same with many most strong reasons not needful here to be rehearsed, because I think fewe or none do doubt thereof, and especially the holy Scripture affirming the foundations of the earth to be layd so sure that it neuer should mooue at any time: Again you shall find in the self same Psalme these

[129] Thomas Blundeville, *His Exercises* (London: John Windet, 1594), sig. 181*r*. http://eebo.chadwyck.com.echo.louisville.edu/search/full_rec?SOURCE=pgimages.cfg&ACTION=ByID&ID=99838324&FILE=../session/1303969253_13772&SEARCHSCREEN=CITATIONS&VID=2698&PAGENO=191&ZOOM=100&VIEWPORT=&SEARCHCONFIG=var_spell.cfg&DISPLAY=AUTHOR&HIGHLIGHT_KEYWORD=undefined. (accessed 28 April 2011). See also Russell, "The Copernican System in Great Britain," 196. It is unclear why Blundeville gave 1536, seven years too early, as the publication date for *De revolutionibus.*

> words, Hee appointeth the Moone for certain seasons, and the sunne knoweth his going downe, whereby it appeareth that the sunne mooueth and not the earth.[130]

Somewhat ironically, eight years later in his *Theoriques of the Seven Planets*, Blundeville named the German astronomer Michael Maestlin, a Copernican, as his chief astronomical influence for planetary calculations. *Theoriques*—usually referred to as *theorica*—were traditional astronomical textbooks dating back to the twelfth century similar to ephemerides like John Feild's *Ephemeris anni 1557*. However, rather than simply providing tables with values for determining the positions of heavenly bodies at given times and places, *theorica* typically included the specific calculations one needed to master in order to predict these positions oneself.[131] Blundeville, following the mathematical models of Maestlin, which were themselves derived from Copernicus, wrote in the introduction to his *Theoriques* that

> I thought I could not shew myself more thankfull vnto them [the court of the Earl of Leicester] than by setting forth the Theoriques of the planets, which I have collected, partly out of Ptolemy, and partly out of Puerbachius, and of his commentator Reinhold, also out of Copernicus, but mostly out of Mestelyn, whom I have chiefly followed because his method and order of writing greatly contenteth my humor.[132]

Maestlin taught traditional Ptolemaic astronomy at the University of Tübingen, but he adhered fully to heliocentrism in his research and writing by at least the 1590s, even if he

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[130] Blundeville, *His Exercises*, sig. 181*r*.

[131] Katherine A. Tredwell, "*Theorica Planetarum*," in *Medieval Science, Technology, and Medicine: An Encyclopedia*, ed. Thomas Glick, Steven John Livesey, and Faith Wallace (New York: Routledge, 2005), 474-5. The first of these textbooks was written in early thirteenth century by Gerard of Sabloneta, often confused with the earlier translator Gerard of Cremona. The most famous and most widely used *theorica* throughout the Later Middle Ages up to the sixteenth century was John of Sacrobosco's *Tractatus Sphaera* of ca. 1230.

[132] Thomas Blundeville, *The Theorique of the Seven Planets* (London: Phillip Islip, 1602), sig. Aiii*r*. http://eebo.chadwyck.com.echo.louisville.edu/search/full_rec?SOURCE=pgimages.cfg&ACTION=ByID&ID=99852660&FILE=../session/1303969554_14395&SEARCHSCREEN=CITATIONS&VID=17994&PAGENO=3&ZOOM=50&VIEWPORT=&SEARCHCONFIG=var_spell.cfg&DISPLAY=AUTHOR&HIGHLIGHT_KEYWORD=undefined. (accessed 28 April 2011).

was reticent to publish any polemics against Ptolemaic astronomy.[133] Blundeville's invocation of him, along with other luminaries of the astronomical canon, demonstrates not only his reliance on numerous historical astronomers for his calculations but also his ability to accept Copernican mathematics without accepting its physical reality.

The final important figure in the reception of Copernicanism in England before the 1610s was Thomas Harriot. Harriot was remarkable yet enigmatic figure in the history of science. Called "the English Galileo" by his most authoritative biographer John W. Shirley, Harriot became most famous for his telescopic observations of the contours of the moon's surface and sunspots, which he called "frost & a mist [on] the sonne" some four months prior to the same discoveries by Galileo.[134] However, Harriot's precarious position at court during the first decade of the seventeenth century, which we shall examine in more detail in the next chapter, made it difficult for him to achieve any recognition for his scientific works during his lifetime.

Harriot's role in the reception of Copernicanism in England was at once important and negligible—it was important in that he was the last major figure to fully support Copernicanism before Galileo's observations provided, for the first time, physical evidence for Copernicanism, and because Harriot's own observations helped convince him of heliocentrism. However, he attained only marginal scientific status and exerted

[133] See Kuhn, *The Copernican Revolution*, 187; Westman, "The Copernicans and the Churches," 85 and 98; and Robert Westman, "Michael Mästlin's Adoption of the Copernican Theory," in *Colloquia Copernicana* 4, Studia Copernicana 13 (Wrocław: Ossolineum, 1975).

[134] Stephen P. Rigaud, "Account of Thomas Harriot's Astronomical Papers," in *Miscellaneous Works of James Bradley* (Oxford, 1832), quoted in Allan Chapman, "The Astronomical Work of Thomas Harriot," *Quarterly Journal of the Royal Astronomical Society*, Vol. 36 (2004): 102. See also John W. Shirley, "Sir Walter Ralegh and Thomas Harriot," in *Thomas Harriot, Renaissance Scientist*, ed. John W. Shirley (Oxford: Oxford University Press, 1974), 16-35.

little influence over other scholars because he was an intensely private and timid scholar after his brief incarceration in the Tower of London in 1605.[135] Harriot remained relatively obscure because he published only one work during his lifetime, *A Briefe and True Report of the New Found Land of Virginia*. This ethnographic description of the Algonquian people and language, which he made during his 1585-6 voyage to the coast of modern-day Virginia and North Carolina, contained no indication of his astronomical or mathematical beliefs despite the fact that these pursuits were his primary professional concern.[136] His only other published work was the *Artis Analyticae Praxis*, which came ten years after his death, and it contained no insight into his opinion on Copernicanism.

The main clues to Harriot's acceptance of the heliocentric theory came in the letters he exchanged with several other scientists, including, most notably, Johannes Kepler. However, Harriot's correspondence with his pupil Sir William Lower revealed the most about his opinions on astronomy. Unfortunately, all of Harriot's letters to Lower have disappeared, but nine letters from Lower to Harriot remain, and they present a picture of Harriot as highly knowledgeable in mathematics, optics, and observational astronomy but reserved in his demeanor and uninterested in the kind of glory-seeking that often typified upwardly mobile courtiers during this time period.[137] Lower rarely mentioned Copernicus himself, and instead, most of the references that shed light on Harriot's attitude toward the heliocentric theory occurred as discussions of the various observational details that supported this viewpoint. Lower, who professed to Harriot that

[135] Pumfrey and Dawbarn, "Science and Patronage in England," 163; John W. Shirley, *Thomas Harriot: A Biography* (Oxford: Oxford University Press, 1983), 351-79.
[136] Shirley, *Thomas Harriot: A Biography*, 70-112.
[137] Ibid., 391-2.

he was "wholly possessed with astronomical speculations and desires," received an early telescope from Harriot in 1610 and immediately recognized how essential it would become to astronomy in the future.[138] Following Harriot's instructions, Lower used a telescope to observe the details of moon's surface. "I have received the perspective cylinder [telescope] that you promised me," Lower wrote to Harriot,

> [and] according as you wished I have observed the moon in all its changes. In the new I manifestly discover the earth shine, a little before the Dichotomy, that spot which represents unto me the Man in the Moon (but without a head) is first to be seen. A little after near the brim of the gibbous parts toward the upper corner appear luminous parts like stars but much brighter than the rest and the whole brim along, looks like unto the Description of the Coasts in the Dutch book of voyages…I must confess I can see none of it without my cylinder.[139]

By observing features on the surface of the moon, both Harriot and Galileo disproved the Aristotelian notion that heavenly bodies were perfectly spherical. Just as Galileo emphasized the telescope as an essential scientific instrument in the Medici court in Tuscany, Harriot employed it to make simultaneous observational discoveries in England.

Though direct references to Copernicus were scant in these exchanges, Lower complained of those who spoke "slightly of Copernicus" without understanding him, and he defended Kepler, who had criticized the French mathematician François Viète for his constant "mend[ing] of things in…Copernicus," signifying that he, and presumably Harriot, concurred with Copernicus in general terms.[140] The principal concern of Harriot and Lower, however, seems to have been the removal of the last vestiges of Aristotelianism in the Copernican system. The observations of Galileo, Harriot, and

[138] Letter from Sir William Lower to Thomas Harriot, [undated], in *The Elizabethan Reader*, ed. Hiram Haydn (New York: Penguin, 1955), 141-2.
[139] Ibid.
[140] Ibid.

others had undermined the notion of the perfection of the superlunar sphere and the idea that the planets were carried about in their orbits by invisible, solid crystalline spheres. Now, along with Kepler, who Lower claimed to have "read diligently" at the behest of Harriot, they were attempting to remove the final Aristotelian axiom of the perfectly circular motion of the planetary orbits.[141] Harriot and Lower had both obviously read Kepler's recently published *Astronomia Nova*, which offered the first observational evidence for the elliptical orbit of the planets, and Lower wrote to Harriot that "about his theory [elliptical orbits]… methinks (although I cannot yet overmaster many of his particulars) he established soundly and as you say overthrow the circular astronomy."[142] With Kepler's discovery of the elliptical orbits of the planets, the final remnants of the Ptolemaic and Aristotelian cosmos had been disproved. This opened the door for a new kind of physics and a new kind of empiricism, both of which affected the practice of judicial astrology.

The reception of Copernicanism in England was a slow process that went through several phases. From its first appearance in print as an intriguing mathematical novelty in 1556 to its first unqualified acceptance as a physical reality by Digges in 1576 to its acceptance based on observational evidence by Harriot in the 1610s, astronomers and astrologers reacted to Copernicanism in a variety of ways. While it did not immediately undermine the Ptolemaic-Aristotelian system, its mathematical solutions to the problem of how to precisely predict planetary movements could not be ignored by any knowledgeable astronomer or astrologer by the end of the seventeenth century. Few

[141] Ibid., 143
[142] Ibid.

accepted it as a physical reality at first, but many "semi-Copernicans" accepted its mathematical description of the cosmos without question. In England, the largely practical, utilitarian concerns of patrons and their client-scientists meant that as long as Copernican mathematics provided more precise planetary positions, the heliocentric theory would grow in influence.

CHAPTER THREE

COPERNICANISM AND ASTROLOGY IN SIXTEENTH-CENTURY ENGLAND: PATRONAGE AND PRACTICALITY

By the time Copernicanism gained a foothold in England, judicial astrologers had become fragmented into many distinct camps including philosophical conservatives, mathematical reformers, and popular prognosticators.[143] The conservatives maintained a version of astrology based on a wide range of astrological traditions and were not particularly interested in mathematical precision. Among these astrologers who practiced judicial astrology in the way it had been conducted since ancient times, Copernican mathematics made little headway.[144] Among conservative astrologers less interested in mathematics or less adept in the precision necessary for utilitarian astrology, the impact of occult philosophies such as Neoplatonism and Hermeticism held greater sway and they

[143] See Campion, *A History of Western Astrology*, 99-132; and Bowden, *Scientific Revolution in Astrology*, 62-107 and *passim*. Bowden was among the first scholars to describe the changes to sixteenth century astrology as "reform." Campion argues that there are two macro-groups—the conservatives and the reformers—and then goes on to further subdivide them. One group of conservatives practiced astrology as they always had, while the other specifically sought out "non-scientific" methods of astrological prognostications. They ignored the quantitative aspects of astrology in favor of the qualitative aspects found in Neoplatonic and Hermetic thought. These philosophical systems each maintained that the celestial bodies exerted great influence over mankind, but their adherents averred that these influences could not be determined by a more careful examination of the stars. As for the reformers, Campion divides them into two groups as well: those who sought to reform astrology by making knowledge of planetary positions more precise and those who sought to restore astrology to a "textual correctness" based solely on the writings of Ptolemy. For the purposes of this study, I am treating the conservatives as a single group because Copernicanism appears to have asserted virtually no influence over them, while for the reformers, I am primarily concerned with former group, because they appear to have been the most prominent group of astrologers practicing within the English patronage system. Popular astrologers mostly originated from the reformers, but by the time they achieved prominence in the mid-seventeenth century, they felt little need to emphasize their use of mathematics. See Chapter 4 below for more on popular astrologers.

[144] Campion, *A History of Western Astrology*, 105.

practiced astrology based on divination or magic.[145] The new cosmology and mathematics of Copernicus had little effect on how they understood the fundamentals of astrology, and these astrologers generally wrote books of commentary or theory on the subject of judicial astrology instead of practicing everyday prognostication.[146] Popular astrologers, sometimes referred to as "vulgar astrologers" by their elite detractors, were typically not scientists, and their prognostications came in the form of non-mathematical, usually non-technical almanacs.[147] However, during the sixteenth century, conservative and popular astrologers practiced mainly outside the utilitarian patronage system of Tudor and Stuart England. Astrological reformers took the criticisms of writers like Pico della Mirandola to heart and sought to establish judicial astrology as a precise, mathematical science. The practical concerns of English patrons ensured that these mathematical reformers flourished at court, where client-scientists' interests in mathematical precision paralleled their patrons' insistence on scientific proof.[148]

Conservative astrologers rarely commented on the scientific debate between Ptolemaic and Copernican theories. Typical of the conservative position on astrology, for

[145] Ibid.
[146] Ibid., 99-104.
[147] H. Darrell Rutkin, "Astrology," in *The Cambridge History of Science: Early Modern Science*, Vol. 3, ed. Katherine Park and Lorraine Datson (Cambridge: Cambridge University Press, 2006), 553. In the sixteenth century, almanacs had been quite technical and often showed examples of the mathematical techniques employed in determining the positions of the planets or in the casting of horoscopes. Throughout the mid to late seventeenth century, however, almanacs dropped most of their mathematical demonstrations. The only exception seems to have been in the science of navigation, and mathematical demonstrations in that field seem to have increased in popular works throughout the period. See also Bernard Capp, *English Almanacs, 1500-1800: Astrology and the Popular Press* (Ithaca, NY: Cornell University Press, 1979), 199-201; and Chapter 4 below for more details.
[148] I have used the term "client-scientist" throughout this work to refer to scientists patronized by the nobility who derived their main source of income or secured funding for their research through their patrons. Most historians of patronage refer to these individuals simply as "clients" and their relationship as "patron-client." To avoid confusion related to the modern meaning of the term "client," which implies that a service is being performed *for* them rather than *by* them, I have used the somewhat cumbersome, but more precise term, "client-scientist."

example, was the Italian theologian and astrologer Tommaso Campanella, who wrote that "whether the sun moves or stands still, it is to be supposed a moving planet by us, considering the matter from our senses and our description; for the same happens whether it moves or the earth."[149] Campanella, like many other astrologers more interested in the metaphysical, emphasized that it was only the *relative* position of the stars in sky and their relationship with the individual for whom a horoscope was cast that mattered. Similarly, in England, the great astrological defender Sir Christopher Heydon, in his *Defence of Iudiciall Astrologie*, argued that "whether (as Copernicus saith) the earth be not the centre of the world, the astrologer careth not," because astrology was consistent with both geocentric and heliocentric models of the cosmos.[150]

While this was true on a theoretical level, it was not necessarily true on a practical level because knowledge of the precise locations of the planets coincided better with the interests of nobles whose patronage those reform-minded astrologers required. Therefore, those who wished to curry favor of potential patrons emphasized this precision.[151]

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[149] Tommaso Campanella, *Astrologia libri sex*, Book 1, Chapter 2, quoted in Tester, *A History of Western Astrology*, 214. Campanella actually was a client-scientist of Pope Urban VIII for five years (1629-1634) though, like most continental models, this form of patronage was highly ostentatious and much less concerned with the practical details concerning the mathematics of planetary location.

[150] Christopher Heydon, *A Defence of Iudiciall Astrologie*, (London, 1603), 371. In one sense, Heydon is an aberration to the patronage model in England, though as a noble himself, Heydon required no support based on his practicing of astrology. This work was written in response to John Chamber's anti-astrological diatribe *A Treatise Against Iudiciall Astrologie* (London, 1601) and Heydon appealed to multiple strains of astrological thought in order to defend judicial astrology as a science, though he obviously believed that astrology could certainly exist within either a geocentric or heliocentric cosmos.

[151] Campion, *A History of Western Astrology*, 106. See also Garin, *Astrology in the Renaissance*, xi and 83-112; Patrick Curry, *Prophecy and Power: Astrology in Early Modern England* (Princeton: Princeton University Press, 1989), *passim*; and Cameron, *The Star-Crossed Renaissance*, 47-100 and *passim*, for discussions of the differences between those astrologers who emphasized precise measurements of the motions of the heavenly bodies and those who emphasized incantations and spells as the true method for more accurate prediction. Garin argues that Renaissance astrology was a confrontation between two worldviews that could seek less common ground throughout the Scientific Revolution: the "rational order" derived from Greek science and the "myths and superstitions" derived from the East. He defined it,

Typical of the astrological reformers was the Dutch polymath Gemma Frisius, whose very early realization of the impact of Copernicanism on astrology is telling. Two years prior to Copernicus's death and the publication of his *De revolutionibus* in 1543, Frisius received a copy of Georg Joachim Rheticus's *Narratio Prima*, the first printed exposition of the heliocentric theory. Frisius, a student of medicine at the University of Louvain, immediately recognized the utility of the theory and expected that its application would remedy the mathematical inaccuracies of Ptolemaic astrology. In the summer of 1541, he wrote to John Dantiscus, the bishop of Ermland, lamenting that "many errors, veils, and many labyrinths…many puzzles more difficult than the Sphinx have enveloped our astrology," and he believed heliocentrism was the key to unraveling them.[152] Among the dilemmas he supposed new astronomical tables based on Copernican mathematics would solve, Frisius specified

> the motion of Mars, which I have often found to differ by three elliptical degrees from even the most exact calculation with astronomical tables. Or the size of the Moon, which does not vary as much before our eyes as the most reputable authors of this art maintain. The length of the year has never been determined in perfect accordance with the truth… The motion of the firmament and the apogees, which, not even resembling a slight resemblance to the truth, is ridiculed by all. I also leave aside several other things on the longitude and latitude of nearly all the fixed stars… If that author [Rheticus] would mend and buttress these matters…wouldn't it amount to giving us a new earth, a new heaven, and a new world?[153]

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somewhat hyperbolically, as a choice between "logic and magic, mathematics and mythology, Athens and Alexandria."

[152] John Dantiscus, *Correspondence*, ed. De Vocht, 344-347, quoted in Stephen Vanden Broecke, *The Limits of Influence: Pico, Louvain, and the Crisis of Renaissance Astrology* (Leiden, Netherlands: Koninklijke Brill, 2003), 150. "*…enim erroribus, involucres, labyrinthis…deninque aenigmatibus plus quam Sphincigis involutam habuimus nostrum Astrologium…*" Translation adapted from Stephen Vanden Broecke.

[153] Ibid., 147. "*…quod Martus motum saepe a calculo, vel exactissimo secundum tabulus, tribus signiferi partibus absesse observaverim. Quod Lunae magnitudonon tantum verietur ad nostrum conspectum, quantum notant gravissimi hujus artis auctores. Quod anni quantitas nunquam inventa sit exacte conformis veritate…motu Firmamenti et Apogiorum, qui ut ne umbram quidem habuit veritatis, ita omnibus ridenus*

Frisius's assessment of the problems plaguing contemporary astrology depended heavily on a detailed knowledge of observational and mathematical astronomy, and he seemed keenly aware that any meaningful reform in astrology would hinge upon the increased precision of observational astronomy. With the coming of Copernicus's longer work two years later, Gemma Frisius, and other astrologers, got their wish. For Frisius, *De revolutionibus* was a key mathematical resource for the better prediction of the position of the stars and planets. For those who were beginning to regard the precision of planetary positions as the primary characteristic of a legitimate astrology, this work, and the tables derived from it, provided a significantly more accurate basis for mathematical calculations concerning these locations. From the very beginnings of Copernican astronomy, its relevance for astrological prediction was apparent for those who chose to utilize it.

Meanwhile, in England, once the Copernican theory had taken root, astrologers recognized that its mathematics could be employed to benefit judicial astrology. For example, in 1583 Thomas Heath wrote a treatise on judicial astrology in order to correct the errors of a previous work by Richard Harvey, whom Heath regarded as a poor astrologer because he lacked the mathematics necessary to make the proper calculations. Despite his work's pessimistic tone, Heath was not anti-astrological. Rather, he urged people not to lose faith in astrology because of the mathematical errors of a few, and he

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approbatur. Omitto etjam plura alia de omnium fera stellarum longitudine et latitudine…Haec si reddiderit auctor ille sarta et tecta…nonne hoc est novam dare terre, novam coelem, ac novam mundum." The translation is Vanden Broecke's. For more information on Gemma Frisius's interpretation of the Copernican impact on astrology, see also John David North, *The Universal Frame: Historical Essays in Astronomy, Natural Philosophy, and the Scientific Method* (London: Hambledon Press, 1989), 17-32.

referred to those not familiar with "Copernicus'…[h]ypotheses, Reinholt's observations, or Puerbachius' [tables]" as "simple Astrologians."[154] Harvey's work became popular because it predicted terrible events for the year 1588, when a conjunction of Jupiter and Saturn was to occur. According to contemporary chronicler Raphael Holinshed, much of the populace of England had reached a point of near hysteria with talk of the prediction "rife in everie mans mouth."[155]

Thomas Heath assuaged the fears of the English by claiming that Harvey made erroneous predictions based on bad data. He criticized Harvey for employing out-of-date tables for his calculations and for failing to understand the observable motion of the planets. "It is well known," chastised Heath, that Harvey "followed the Alfonsine account, which at this day is long since found (by the best learned) to halt, prooved insufficient, exactly to account any apparent motion."[156] For those astrologers who kept abreast of the latest mathematical tables, the consultation of the Alfonsine tables for planetary positions would have immediately indicated to the mathematically educated astrologer the inadequacy of a work. The Prutenic tables had largely replaced the Alfonsine table by the 1580s, and because Harvey had used these for all of his planetary

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[154] Thomas Heath, *A manifest and apparent confutation of an astrological discourse, lately published to the discomfort (without cause) of the weake and simple sort* (London, 1583), sig. B7*v*. http://eebo.chadwyck.com.echo.louisville.edu/search/full_rec?SOURCE=pgimages.cfg&ACTION=ByID&ID=99841827&FILE=../session/1303969891_14948&SEARCHSCREEN=CITATIONS&VID=6440-01&PAGENO=16&ZOOM=100&VIEWPORT=&SEARCHCONFIG=var_spell.cfg&DISPLAY=param%28DISPLAY%29&HIGHLIGHT_KEYWORD=undefined. (accessed 28 April 2011). Heath's work was a direct reply to Richard Harvey's *An astrological discourse Upon the Great and notable Coniunction of the two superior Planets, Saturne and Iupiter, which shall happen the 28. day of April, 1583*. See also Allen, *The Star-Crossed Renaissance*, 124-125.

[155] Raphael Holinshed, *Holinshed's Chronicles* (London, 1587), quoted in Anna Geneva, *Astrology and the Seventeenth Century: William Lilly and the Language of the Stars* (Manchester: Manchester University Press, 1995), 135.

[156] Heath, *A manifest and apparent confutation of an astrological discourse*, sig. B1*r*

positions, his calculations were off by more than fifteen hours. According to Heath, this created what "needs be a greate alteration in iudgement" and because of the discrepancy, Heath predicted that the conjunction was benign rather than malevolent.[157] Heath admonished Harvey for his lack of precision and instructed that "not only to the degree and minute [of arc] is requisite but also the second, where at any time the coniunction may happen," reminding his fearful audience that even seemingly minor errors could create wildly different predictions.[158]

The satirist and notable astrological skeptic Thomas Nashe was much less forgiving in his treatment of Harvey in particular and credulous commoners more generally. In his 1589 pamphlet *Anatomy of Absurdity*, Nashe ridiculed those who interpreted every stellar event as a cause for alarm, writing that "no star [Harvey] seeth in the night but seemeth a Comet; he lighteth no sooner on the quagmire, but he thinketh this is the foretold earthquake… Thus are the ignorant deluded, the simple misused, and the sacred Science of Astronomy discredited."[159] Nashe considered astrologers like Harvey reckless and sensationalist and he implied that Harvey had taken advantage of people's fears to sell his work. For Nashe, the fact that so many had prophesied doom for the year 1588 and this had not come to pass was proof that "the distemperature of the stars," as he put it, was nothing more than a fiction.[160] In another pamphlet published three years later, Nashe referred to Harvey as a "ridiculous Ass" and recommended that

[157] Ibid.
[158] Ibid., sig. B2*r*.
[159] Thomas Nashe, "The Stars' Distemperature Disproved," from *The Anatomy of Absurdity* (1589), in *The Elizabethan Reader*, ed. Hiram Haydn (New York: Viking Press, 1955), 135.
[160] Ibid.

any astrologer whose predictions turned out to be manifestly false should be shunned by the profession and never heeded again:

> What expectation there was in both town and country , the amazement of those times may testify: and the rather because he pawned his credit upon it, in these express terms: "If these things fall not out in every point as I have wrote, let me forever hereafter lose my credit in Astronomy." Well, it so happened that he happened not be a man of his word; his Astronomy broke that day with his creditors, and Saturn and Jupiter proved honester men than all the World took them for.[161]

Furthermore, the year 1588 was witness, not to cataclysm, but to one of the most decisive English military victories of the century with the defeat of the Spanish Armada, and this damaged the reputation of astrologers who had predicted terrible events for the year. Indeed, the reputation of Richard Harvey and those associated with him declined throughout the 1590s.[162]

Despite the increased attention to results in the realm of astrological prediction, Harvey was able to retain some degree of respectability in England due in large part to the patronage of the Bishop of London. This was fairly typical of astrologers in the sixteenth century. In England, astrologers appropriated this information primarily in ways that suited the needs of their patrons. Nearly all members of the higher nobility in sixteenth-century England employed astrologers at their courts, and the astrologers' duties typically involved observing the sky or more often consulting with mathematical tables and making prognostications based on this information. Because the sixteenth century witnessed not only a consolidation of the centralized state under the powerful Tudor family but also the economic expansion of England overseas, the nobility became

[161] Thomas Nashe, *Pierce Penniless, His Supplication to the Devil*, in *The Elizabethan Reader*, 135-6.
[162] Allen, *The Star-Crossed Renaissance*, 125-6.

increasingly aware of the need for well-educated scholars, highly qualified to utilize various branches of knowledge in service of their interests. Frequently, the same individuals involved in surveying and mapping a lord's estate or designing the fortifications for a castle were also using the similar mathematical techniques of astrology to prognosticate the future.[163]

Many of the most illustrious courtiers of the Elizabethan era displayed an eager interest in the knowledge of astrology. Robert Dudley, the Earl of Leicester, employed two astrologers personally—one as his physician, another specifically for the casting of horoscopes—and it was at his request that John Dee determined the most auspicious moment for the coronation of Elizabeth I in 1558. William Cecil, Lord Burghley, evidently kept a notebook detailing astrological predictions, and Henry Percy, Earl of Northumberland, cultivated a circle of client-scientists rich in practicing astrologers who were knowledgeable in the mathematics necessary to precisely predict planetary locations.[164] Puritan theologian Laurence Humphrey exaggerated little when he remarked in 1563 that most among the nobility "ravened, embraced, and devoured" the science.[165] Since reformist astrologers focused on the precise mathematical basis necessary for prediction, patrons' utilitarian interests led them to employ more reform-minded, mathematical practitioners. For example, in his capacity as a medical practitioner, Robert Recorde served as a court physician to both the young King Edward VI, to whom he dedicated several books, and his successor Queen Mary, to whom he dedicated *The*

[163] Eamon, *Science and the Secrets of Nature*, 223; Pumfrey and Dawbarn, "Science and Patronage in England," 140 and 142.
[164] Thomas, *Religion and the Decline of Magic*, 290.
[165] Laurence Humpfrey, *The Nobles: or of Nobilitye* (London,1563), sig. Yvi*v*, quoted in Thomas, *Religion and the Decline of Magic*, 290.

Castle of Knowledge.[166] Recorde's treatment of both astrology and astronomy in this work exemplified the concatenation of these two fields of study in the mid-sixteenth century and the significance of mathematics for the study of both.

Though wholly astronomical and mathematical in content, as we have seen, *The Castle of Knowledge* contained a preface insinuating that the entire enterprise of mathematical astronomy was important in the first place because that knowledge gave men control over the impact of the stars:

> So was there never anye greate chaunge in the worlde, nother translations of Imperies, nother scarse falle of anye princes, nor dearthe and penurye, no death and mortalitie, but GOD by the signes of heaven did premonish men therof, to repent and beware betyme, if they had any grace. The examples are infinite, and all histories so full of them, that I thinke it needles to make any rehearsall of them more; especially seeyng thei appertain to the Iudiciall part of Astronomy, rather than to this part of the motions, yet shall it not be preiudiciall… But who that can skyll of their natures, and coniecture rightlye, to affect them and their menacynges, shall be able not only to avoide many inconveniences, but also to achieve many unlikelye attemptes, and in conclusion be a governoure and rulare of the stars…[167]

Like many other early modern scholars sympathetic to astrology, Recorde was eager to refute any charges of determinism that often accompanied the practice of astrology.[168] Far from succumbing to power of the stars, astrologers often believed that greater knowledge of the movement of the stars allowed men greater control over their destinies—precisely the type of practical control patrons coveted. Just as the practical knowledge of mathematics provided control over the earth through the arts of navigation

[166] Geoffrey Howson, *A History of Mathematics Education in England* (Cambridge: Cambridge University Press, 1982), 6-8.
[167] Recorde, *The Castle of Knowledge*, sig. A5*r*-A6*v*.
[168] Tester, *A History of Western Astrology*, 224; Johnson, *Astronomical Thought in Renaissance England*, 126.

and cartography, so too could it provide mastery, rather than subservience, to the power of the stars over human affairs.

Thomas Digges left fewer clues regarding his specific opinion on astrology, though it seems very likely that he had cast some horoscopes and given his opinion on the meaning of stellar events, such as the 1572 supernova and 1577 comet. Both of Digges's principal patrons—William Cecil, Lord Burghley and Robert Dudley, the Earl of Leicester—were interested in astrological prognostication. In the 1570s, Digges offered both Burghley and Leicester "astronomical manuscripts" for the purposes of better practicing astrology.[169] In a lost manuscript dedicated to Lord Burghley, Digges had included multiple tables designed to determine the positions of the stars and planets in relation to the horizon, meridian, sun and moon. In the treatise, Digges evidently included "sundry conclusions both pleasant for variety of knowledge and necessary for common use" in which he rendered conclusions for "Histories poetical and Judgements astronomical."[170] It is unclear whether, by "Judgements," he meant astrological predictions or definitive information on their positions in the sky, but given Burghley's obvious interest in mathematical astrology, it is likely that this referred to both.[171] In a letter to Lord Burghley, Digges claimed he had "waded as far as ancient grounds of astrology would bear him to sift out the unknown influences of this new star or comet,"

[169] British Library, Lansdowne MS 19.30, printed in James Orchard Halliwell (ed.), *A Collection of Letters Illustrative of the Progress of Science in England* (London, 1841), 6-7, quoted in Johnston, "Like Father, Like Son? John Dee, Thomas Digges, and the Identity of the Mathematician," 69.
[170] Ibid.
[171] Ibid.

and he would "[s]end notes of observation and prediction" at a later time.[172] Given his views on heliocentrism, it also seems likely that he used Copernican tables for the purposes of these predictions.

In the one explicit mention of astrology in his work expounding upon Copernicanism, Digges claimed that "sundry Astrologians finding the alterations in the declination and Longitude of stars, have thought that the same also should have his motion peculiar," by which Digges meant that there existed a discrepancy between the way that stars attached to a solid crystalline sphere *should* move, and the way they *do* move because of the changing position of the earth in its orbit. "Yet Copernicus," Digges continued, "by the motions of the Earth, solveth all, and utterly cutteth off the ninth and tenth spheres, which contrary to all sense, the maintainers of the earth's stability have been forced to imagine."[173] In the Ptolemaic system, the eighth sphere was that of the fixed stars, the ninth sphere was called the *primum mobile* (prime mover), and it existed to keep the stars in motion, and the tenth sphere was the "Emyrean realm" of God and the angels. Copernicus removed the ninth and tenth spheres from his physical description of the cosmos, but maintained the sphere of fixed stars at the very edge.[174] In any case, Digges was clearly interested in both the Copernican conception of the cosmos as well as the fact that its mathematics provided astronomer-astrologers with more precise positions of planets.

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[172] Letter from Thomas Digges to Lord Burghley, 14 May 1574, NL MS. Landowne 19.30, quoted in Pumfrey and Dawbarn, "Science and Patronage in England," 183 n.94.

[173] Thomas Digges, *A Prognostication Everlastinge of Right Goode Effecte*, sig. N3*v*.

[174] Ibid., sig. M1*v*-*r*. Digges would go one step further than Copernicus by removing the sphere of fixed stars and opening up the cosmos to infinite size. If there were infinite stars extending in infinite directions, it would make determining their effects on the earth all but impossible. See Alexandre Koyré, *From the Closed World to the Infinite Universe* (Baltimore: The Johns Hopkins University Press, 1957), 28-49.

Among the earliest English astrologers to utilize Copernican mathematics specifically in service of his patron was the mathematician John Blagrave. One of Blagrave's principal patrons was Charles Howard, the first earl of Nottingham and Lord High Admiral of the English fleet, which he had commanded at the defeat of the Spanish Armada in 1588. One of the wealthiest and most powerful men at both Elizabeth I and James I's courts, Howard patronized a number of scientists and literati throughout his lifetime.[175] In the dedication to his 1596 study of the astrolabe, Blagrave personally thanked Howard for "taking a personal interest in [his] personal preference" by which he meant his acceptance of the Copernican theory.[176] Blagrave had mentioned Copernicanism as early as 1585, in an earlier text on the mathematics of using an astrolabe, *The Mathematical Iewel*, in which he acknowledged the complexities and inadequacies of the Ptolemaic system, but did not fully commit to the Copernican system as better or more accurate, writing that

> Insomuch that the late yeares that singular man Copernicus affirmeth that the sunne is the fixed centre of the world, about whom the earth moueth (not the sunne about the earth) and that all the rest of the planets moue regularly about the center of the sunne sauing the moone which like an epicicle moueth about the earth in a spheere of the earth 13 times in his yearley motion. But omitting the inuentions of Copernicus, and a number of the rest, I will only heere shew a figure of those which haue always bene before his time…[177]

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[175] See Robert W. Kenny, *Elizabeth's Admiral. The Political Career of Charles Howard, Earl of Nottingham, 1536-1624* (London: The John Hopkins Press, 1970).

[176] John Blagrave, *Astrolabium vranicum generale* (London, 1596), sig. A2*r*. See also Pumfrey and Dawbarn, "Science and Patronage in England, 1570-1625: A Preliminary Study," 152 and 182 n.65.

[177] John Blagrave, *The Mathematical Iewel* (London, 1585), 11. http://eebo.chadwyck.com.echo.louisville.edu/search/full_rec?EeboId=99898549&ACTION=ByID&SOURCE=pgimages.cfg&ID=99898549&FILE=..%2Fsession%2F1303971671_18464&SEARCHSCREEN=CITATIONS&VID=173172&PAGENO=13&ZOOM=100&VIEWPORT=&CENTREPOS=&GOTOPAGENO=&ZOOMLIST=100&ZOOMTEXTBOX=&SEARCHCONFIG=var_spell.cfg&DISPLAY=AUTHOR. (accessed 28 April 2011).

This was the only mention of Copernicus in the text, and Blagrave employed Ptolemaic mathematics and traditional terminology to refer to the cosmos throughout. Still, even at this early stage, Blagrave appears to have recognized the mathematical advantages of the Copernican system.

His next foray into Copernican theory came specifically within the context of judicial astrology, and it appears as though Blagrave was among the reformers who recognized the advantages of tables based on Copernican mathematics. He desired to "skillfully acquaint" astrologers "with all the planets, starres, and constellacions of the heauens…in which, agreeable to the hipothesis of Nicolaus Copernicus, the starry firmament is appointed perpetually fixed and the earth and his horizons continually mouing from west towards the east once about euery 24 houres."[178] In the treatise, Blagrave intended to improve the precision of the astrolabe, a device instrumental in determining the positions of the heavenly bodies, and provide "all such necessary supplements for iudiciall astrology, as Alkabitius & Claudius Dariottus haue deliuered by their tables."[179] With more precise instrumentation and the Copernican model, Blagrave used this to his observational advantage, noting that "…withall being a thynge [astrolabe] most commonly in use, and differing in nothing, but that they according to the auncient Astronomers, appointed the Starry Heavens to move rightwards from East towards West, uppon the earth or fixed horizon of the place."[180] An astrolabe measured the movement of

[178] Blagrave, *Astrolabium vranicum generale*, frontispiece.
[179] Ibid. Blagrave's mentions of "Alkabitius & Claudius Dariottus" refer to a tenth century Arab astrologer, whose *Introduction to the Arts of the Judgment of the Stars* contained planetary tables, and Blagrave's contemporary Claudius Dariot, who made the most common English translation of this work in 1583. It is clear from the context that Blagrave was using Copernican mathematics in service of judicial astrology.
[180] Ibid., sig. F1*v*.

the stars across the sky, which has an apparent east to west motion caused by the daily rotation of the earth in the opposite direction. Although this effect remains the same whether the earth rotates eastward or the fixed stars rotate westward, Blagrave emphasized that the Copernican theory accounted for this movement just as precisely, observing that

> according to Copernicus cause the earth on the horizon to moue leftward from West toward East , uppon the Starry firmament fixed…In which motion (a pretty thing to note) one that standeth by shall hardly perceiue any other but that the *Rete* mooueth although indeede you turne about the Pater, strongly confirming the Copernicus Argument, who sayeth that the weakenesse of the senses do imagine the Heavens to mooue about every 24 houres from East to West by a Primum Mobile, whereas indeed they have been alwayes fixed and it is the earth that whirleth about euery 24 houres from West to East, of his own proper nature allotted unto him, as is most for the receptacle of all transitory things, being appointed in a place where nothing is to stay him from his continuall moouing…[181]

By comparing the rotation of the earth with the similar motion of *rete* across the surface of the astrolabe, Blagrave argued for the physical imperceptibility of the Copernican theory. And his references to both Copernicus and judicial astrologers suggest that he regarded the two as compatible.

The examples of Digges and Blagrave illustrate the control patrons exerted over their client-scientists' astrological works, and if a patron's interest in a topic diminished, they simply ended their support. The drastic shift in Digges's intellectual interests and writings from the 1570s to the 1580s, for example, exemplifies the influence a patron's

[181] Ibid. See also Johnson, *Astronomical Thought in Renaissance England*, 208-210 and Russell, "The Copernican System in Great Britain," 194-195. Russell notes that, much like Digges's appeal to diurnal parallax, this would have made no difference mathematically. However, his juxtaposition of tables specifically designed for judicial astrologers and an exposition and defense of Copernican theory supports the notion that utilitarian astrologers certainly saw some connection between these mathematics and a more precise astrology.

interests had over where a client-scientist's focus would ultimately lie. In the early 1570s, Digges's principal patron had been Lord Burghley but this ended for unknown reasons in 1576.[182] During his time at Burghley's court, Digges's writings concentrated on detailed analyses of stellar events, which, while they had practical implications for horoscopic prognostication, apparently did little to contribute to the wealth of Burghley. From 1578 on, Digges became a highly favored client-scientist of Leicester. Though Leicester accepted astrological prognostication as a legitimate scientific enterprise, he showed less interest in the mathematical astronomy Digges viewed as necessary for such an endeavor. After 1578, with the exception of revised editions of his father's *Prognostication Everlastinge*, Digges published no more on the topic of astronomy or astrology.[183] Instead, under Leicester, Digges used his knowledge of mathematics to compose military treatises on the most effective ways to deploy artillery in battle, on the ballistics of cannonballs and musket shots, and on the provisioning of armies.[184] The reasons for this, as Digges himself wrote in the preface to *Straticos*, his first military work while in the service of Leicester, entailed his devotion to the English state and crown:

> Even so, albeit the strange varietie of intentions in the more subtile part of the Mathematicall Demonstrations did breede in me for a time a singular delectation, yet finding none, or very few, with whom to confer or communicate those my delights (and also remembering the grave sentence of the divine Plato, that we are not born for ourselves, but also for our parents, country, and friends), after I grew to years of riper judgment I have wholly bent myself to reduce those imaginative contemplations to sensible practical conclusions of those my delectable studies, as also to be able, when time is, to employ them to the service of my prince and country.[185]

[182] Pumfrey and Dawbarn, "Science and Patronage in England," 161.
[183] Ibid. See also Russell, "The Copernican System in Great Britain," 194-195.
[184] Johnston, "Like Father, Like Son? John Dee, Thomas Digges, and the Identity of the Mathematician," 73-78.
[185] Thomas Digges, *Straticos* (London, 1579), sig. A3*r-v*.

Digges suggested that he had moved on to more practical matters for the necessity of the state and that the more theoretical mathematics with which he had engaged in his younger years now benefitted him as he put his knowledge to a use deemed more practical by his patron. Interestingly, Digges considered mathematical astronomy, and not necessarily astrology, the "imaginative contemplation" he had renounced. As service to the state in the form of his patron superseded his personal interests, Digges redefined practicality to exclude his earlier work on planetary positions and Copernicanism.

Similarly, John Blagrave, whose works extolling the Copernican theory had once attracted the attention of several notable courtiers, encountered financial difficulties that curtailed his scientific activity. Blagrave, a man of very limited means, was required to seek out new patrons as his current ones lost interest in his practices. Blagrave had cultivated contacts with a large and diverse body of patrons from the 1580s to the 1600s, deriving support from the aforementioned Charles Howard, as well as the influential William Cecil, Lord Burghley, and the Member of Parliament Sir Francis Knollys.[186] Unfortunately, Knollys died in 1596 and Burghley in 1598. Blagrave wrote regretfully that "time hath bereft me of all my most Honourable Favourers," and, just two years before his death in 1611, he nurtured his relationship with his final patron, James I's privy counselor Sir Thomas Parry, through flattery: "…and only your Honour now succeeding your Honourable Father in place of honour, is the principall hope left unto me, who in my Mathematick… [infancy] both favoured me, and furnished me out of your admirable and generall library, of such mathematickes books, as in those daies were

[186] Pumfrey and Dawbarn, "Science and Patronage in England," 152.

hardly or not elsewhere to be gotten."[187] Blagrave's adulation of Parry likely represented not only an attempt curry favor with a potential financial resource but also a genuine expression of gratitude since Blagrave required the generosity of a noble like Parry in order to accomplish his scientific work. Blagrave dedicated all of his published works to his patrons, and in doing so, he conformed to the pattern of many client-scientists who hoped to maintain good relations at court. However, as patrons lost interest in mathematical astrology throughout the early to mid seventeenth century, their financial support for client-scientists specializing in this field waned as well.

Although patronage remained, broadly speaking, the center of the most advanced scientific activity during the sixteenth and early seventeenth centuries, some notable changes occurred within the system. Henry VIII had self-consciously modeled his own court on the culturally refined courts of Renaissance Italy.[188] Throughout the sixteenth century, the writers, philosophers, and scientists at those courts had successfully enhanced the cultural prestige of their patrons through their writings and scientific research, and Henry VIII hoped to emulate this on a national scale in England. By the time of the reign of Elizabeth, as we have seen, the courts had become the center of scientific activity in England. Her long reign, though it had its turbulence, provided a

[187] John Blagrave, *The Art of Dyalling* (London: 1609), sig. A2*v*. http://eebo.chadwyck.com.echo.louisville.edu/search/full_rec?SOURCE=pgimages.cfg&ACTION=ByID&ID=99838337&FILE=../session/1303972014_18872&SEARCHSCREEN=CITATIONS&VID=2712&PAGENO=3&ZOOM=100&VIEWPORT=&SEARCHCONFIG=var_spell.cfg&DISPLAY=AUTHOR&HIGHLIGHT_KEYWORD=undefined. (accessed 28 April 2011). See also Pumfrey and Dawbarn, "Science and Patronage in England," 153 and 182 n.65.

[188] See, for example, Lacey Baldwin Smith, *This Realm of England, 1399-1688* (Lexington, Mass.: D.C. Heath and Co., 1971), 90-108; Norman Davies, *The Isles: A History* (Oxford: Oxford University Press, 1999), 501-529; and Jasper Ridley, *A Brief History of the Tudor Age* (New York: Carroll and Graf, 2002), 179-202.

high degree of stability for the patronization of client-scientists and a relatively open environment for the exchange of scientific ideas.[189] With the coming of the Stuart dynasty in 1603, this began to change. While lines of scientific communication remained open and mostly unobstructed, James I sought more centralization of the court system and exerted a greater level of personal control over what he deemed to be the acceptable and unacceptable practice of science.

King James I's attitude toward astrology was complex but he defined it best in his own scholarly work *Daemonologie*, published in 1597. James was an accomplished scholar in his own right, particularly regarding matters of political theory and statecraft, and *Daemonologie* examined the legal issues concerning magic, witchcraft, and other occult phenomena. While the main topic of this work was to prove "that such deuilish artes haue bene and are" a reality and to determine "what exact trial and seuere punishment they merit," the text contained a definition of astrology, an explanation of its relationship with astronomy, and how to distinguish between the two.[190] Like most scholars of his era, James I discerned between the two concepts of natural and judicial astrology, making explicit references to both the Bible and commonly accepted etymology. But he also was among the first to specifically differentiate between astronomy and astrology—using the original Greek terminology for the words, *astronomia* and *astrologia*—and to consider natural astrology as a category separate from astronomy. He defined astronomy as "the law of the Starres" and claimed that it was "not

[189] See Deborah Harkness, *The Jewel House: Elizabethan London and the Scientific Revolution* (New Haven: Yale University Press, 2007), 1-14 and 142-180.
[190] James I, Stuart, *Daemonologie* [1597], (New York: Barnes and Nobles, 1966), xii.

onelie lawful but necessarie and commendable" because it was a legitimate science based on mathematics.[191] He defined astrology as the "preaching of the Starres" and delineated the natural branch as "knowing thereby the powers of simples, and sickenesses, the course of the seasons and the weather, being ruled by their influence; which part depending vpon the former [*Astronomie*], although it be not of it selfe a parte of *Mathematicques*: yet it is not vnlawful, being moderatlie vsed."[192]According to James I, natural astrology was a perfectly acceptable practice, though it should not be considered a branch of mathematics. Rather, natural astrology was a non-mathematical art that merely relied on the more technical aspects of astronomy.

His treatment of judicial astrology, however, was much less conciliatory. To follow judicial astrology was

> to truste so much to their influences, as thereby to fore-tell what common-weales shall florish or decay: what, persones shall be fortunate or vnfortunate: what side shall winne in anie battell: What man shall obteine victorie at singular combate: What way, and of what age shall men die: What horse shall winne at matche-running…Of this roote springs innumerable branches; such as the knowledge of the natiuities, the *Cheiromancie, Geomancie, Hydromancie, Arithmancie, Physiogmnomie,* & a thousand others. This parte now is vtterlie vnlawful to be trusted in, or practized amongst christians, as leaning to no ground of natural reason…in the Prophet *Ieremie* it is plainelie forbidden, to beleeue or hearken vnto them that Prophecies & fore-speakes by the course of the Planets & Starres.[193]

In this interpretation, James was not so far removed from the tradition of the astrological skeptics who argued that astrology was acceptable provided that it did not contravene

[191] Ibid., 13.
[192] Ibid.
[193] Ibid., 13-14. In this passage, King James makes reference to the prophet Jeremiah, referring to Jeremiah 10:2-3, which states "learn not the way of the nations, nor be dismayed at the signs of the heavens because the nations are dismayed at them, for the customs of the peoples are false." The other arts to which he refers are, essentially, palm-reading, divining by variations in the earth, divining by the ripples in water, divining by numerology, and divining by the face, respectively.

free will. However, by dividing natural astrology from astronomy, James allowed an outlet for *both* a form of astronomy and astrology to be practiced. By singling out the aspects of astrology that he rejected, he was able to relocate the mathematical practice to astronomy and redefine legitimate astrology as an art form separate from and dependent upon the more scientific practice of astronomy.

In terms of its impact on the court patronage system, James I's attitude toward astrology had surprisingly little effect. After James ascended to the English throne in 1603, the nature of the court changed in several ways. New nobles from his native Scotland joined the court, often at the expense of the previous Elizabethan ones; the amount of money funneled into client-scientists actually saw a sharp increase; the court became even more centralized than it had been under either Henry VIII or Elizabeth I; and it took on a more scholarly, professional tone.[194] At first, based on his rhetoric from *Daemonologie*, James seemed to clearly imply that his financial support would extend to astronomy and not to astrology, indicating how separable these two disciplines were perceived to be by the early seventeenth century. Indeed, several astrologers encountered legal trouble under the reign of the first Stuart monarch. As early as 1581, during the reign of Elizabeth I, Parliament had passed laws making it illegal to cast horoscopes for royalty without their permission, and there is evidence that both Robert Cecil, the Earl of Salisbury, and James's son Prince Henry of Wales had banished or imprisoned astrologers for breaking this law.[195] Furthermore, both Henry Percy, the Earl of Northumberland, and his favorite client-scientist Thomas Harriot were imprisoned under

[194] Pumfrey and Dawbarn, "Science and Patronage in England," 166.
[195] Thomas, *Religion and the Decline of Magic*, 344.

James I, in part, because of their illicit use of judicial astrology. Nevertheless, throughout James I's twenty-two year reign, he patronized a number of notable astrologers or active supporters of astrology, including Robert Pont, James Maxwell, and John Napier. Pont was a numerologist and an active supporter of judicial astrology and Napier, best known as the first mathematician to use logarithms, was a disciple of judicial astrology.[196] James I was also a patron and defender of the greatly influential mathematical astrologer and physician Robert Fludd, whose works were among the most widely-read in England in the 1610s and 1620s.[197] Provided that they remain within their legal bounds, James, like his predecessors, allowed astrologers to continue to practice throughout his reign.

Following his ascension to the throne in 1603, James I brought with him from Scotland a whole new coterie of noblemen. Most client-scientists who had established good professional relationships with patrons under Queen Elizabeth I continued to find support among Jacobean nobles. However, with the addition of James's entourage from Scotland, many courtiers from Elizabeth's reign were replaced in important positions at the new monarch's court. Most retained their estates and titles but ceased to serve in any governmental positions for the first Stuart king. In fact, only Robert Cecil, the Earl of Salisbury, one of Elizabeth's favorites, remained directly attached to James's court, and he retained essentially his entire retinue of client-scientists.[198] Other client-scientists

[196] Pumfrey and Dawbarn, "Science and Patronage in England," 167. See also, Arthur H. Williamson, "Number and National Consciousness: The Edinburgh Mathematicians and Scottish Political Culture at the Union of the Two Crowns," in *Scots and Britons: Scottish Political Thought and the Union of 1603*, ed. Roger A. Mason (Cambridge: Cambridge University Press, 1994), 197-99.
[197] Pumfrey and Dawbarn, "Science and Patronage in England," 167-8. See also Bowden, *The Scientific Revolution in Astrology*, 140-6; and Frances A. Yates, *Giordano Bruno and the Hermetic Tradition* (Chicago: University of Chicago Press, 1964), 432-56.
[198] Pumfrey and Dawbarn, "Science and Patronage in England," 156.

faced the decision of remaining with their principal patrons, where they could continue to practice science without any direct royal support, or whether to pursue connections with new nobles. Many chose the latter path.

The court of James I even garnered something of an international reputation in science, particularly because of its utilitarian atmosphere and also because of James's staunch Protestantism. For instance, Johannes Kepler originally hoped to use Jacobean England as a home base for his studies because he viewed King James as the European monarch most capable of uniting the Protestant world and healing the rifts between Protestants and Catholics.[199] Kepler dedicated his *De Stella Nova* of 1606 to James I, and in 1619 he intended to dedicate his *Harmonices Mundi*, which detailed his theory of the harmonic relationship between geometrical ratios and the physically observed heavens, to James I, but the European political situation made it unsafe for him to do so.[200] However, Kepler noted that he hoped his work on celestial harmony would attract the attention of James I, whose hope for "harmony and unity" among Protestants "in the ecclesiastical and political spheres" reflected Kepler's belief in the natural harmony of the celestial spheres.[201] Kepler, who also practiced astrology, believed that James could be persuaded that with the right scientific and mathematical reform, judicial astrology was as valid a science as any.[202] He originally hoped to accomplish this on English soil but ultimately turned down overtures from Henry Wotton, the English ambassador to the court of Holy Roman emperor Frederick II in Vienna, for personal reasons in favor of remaining in

[199] Bowden, *The Scientific Revolution in Astrology*, 108-9.
[200] Ibid., 109.
[201] Ibid.; and Pumfrey and Dawbarn, "Science and Patronage in England," 169.
[202] Ibid.

German lands because he "love[d] the mainland, and fear[ed] the closeness of an island."[203] But it was the Protestant religion and the intellectual openness that drew him to the court of James I.

Many mathematical astronomers who also regularly practiced astrology, such as Johannes Kepler, consciously and categorically separated themselves from non-mathematical astrologers. Kepler's attitudes toward astrology were complicated, but given his scientific influence in England and his attempted connections with the Jacobean court, his positions are important. While he was a practicing astrologer, Kepler was also critical of many of the contradictory rules of traditional astrology, and he was clearly influenced by the criticisms of Pico della Mirandola. Like many of his English counterparts, Kepler regarded a more appropriate application of mathematics as the key to discovering what was valid, scientific astrology, and what was mere superstition. In this respect, Kepler called true astrology the "step-daughter of astronomy" and popular prophecies which relied on no mathematical sciences as "dreadful superstitions."[204] In *De Stella Nova*, Kepler remarked that "a mind accustomed to mathematical deduction, when confronted with the faulty foundations of astrology, resists a long, long time, like an obstinate mule, until compelled by beating and curses to put its foot into that dirty puddle."[205]

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[203] Letter from Johannes Kepler to Johann Matthias Bernegger, 15 February 1621, in James A. Conner, *Kepler's Witch: An Astronomer's Discovery of Cosmic Order amidst Religious War, Political Intrigue, and the Heresy Trial of His Mother* (New York: Harper Collins, 2004), 339.
[204] Johannes Kepler, *De Stella Nova*, in *Gesammelte Werke*, Vol. 1, 147, quoted in Arthur Koestler, *The Sleepwalkers: A History of Man's Changing Vision of the Universe* (New York: Penguin, 1959), 245.
[205] Ibid.

By accepting astrology as scientifically valid, Kepler assumed that he had no choice but to apply his mathematical knowledge to the "dirty puddle" of astrology, thus saving it from its own deficiencies. In a letter to his former mathematics professor Michael Maestlin, in which he ridiculed what he considered both Catholic and astrological superstition, Kepler explained that he proceeded "as the Jesuits do, who correct much in order to make men Catholic. Or rather, I do not act so, for those who defend all the nonsense are like the Jesuits. I am a Lutheran astrologer, who abandons the nonsense and keeps the kernel."[206] Kepler recognized that astrology required serious reform if it were to be regarded as a legitimate science, but he maintained an overall belief that the heavens exerted some influence over the lives of individual humans. It was evident that Kepler relied on the advances in mathematical astronomy to support his reform:

> But if I now speak of the outcome of my studies, what, may I ask, do I find far off in heaven that even remotely refers to it? No inconsiderable part of science, according to the experts, have been either freshly constructed by me, or corrected, or completely finished. But in this regard, my stars were not Mercury rising in the corner of the seventh house 90 degrees from Mars, but Copernicus and Tycho Brahe. Without the latter's volumes of observations everything which has now been brought to me in the clearest light would lie buried in darkness.[207]

Even as Kepler researched the mathematics of the motions of the heavenly spheres, and in the process developed what he is best-known for—the three laws of planetary motion, which disproved Aristotle's perfectly circular spheres—he used much of this knowledge to create a more mathematically precise astrology.

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[206] Letter from Johannes Kepler to Michael Maestlin, 15 March 1598, in *Gesammelte Werke*, Vol. 13, 184, quoted in Bowden, *The Scientific Revolution in Astrology*, 108.

[207] Johannes Kepler, *Harmonices Mundi*, in *Gesammelte Werke*, Vol. 6, 280-5, quoted in Edward Rosen, "Kepler: Astrology and Mysticism," in *Occult and Renaissance Mentalities*, ed. Brian Vickers (Cambridge: Cambridge University Press, 1984), 267.

Among the most notable new courtiers under James I was his own eldest son Henry Frederick, Prince of Wales, the heir-apparent to the English throne. Though only ten years old at his father's coronation, Henry proved a precocious youth interested in traditional chivalric sports such as hunting, but he also seemed eager to apply himself to academics.[208] King James insisted that Henry's education should be the ultimate focus of the court, and this facilitated a great convergence of many of the most learned men in England. According to one of Henry's tutors Sir Thomas Chaloner, James ordered that Henry's household "should rather imitate a college than a court" and that "His Highness' household...was intended by the King for a courtly college or a collegiate court."[209] Similarly, Timothy Bright, a client-scientist who remained attached to the household of the Earl of Salisbury following James's ascension, described life at the Jacobean court as "akin to a university."[210]

Henry's father initially assembled the court for him, but by his early teen years, Henry began amassing many of his own client-scientists, particularly those with scientific knowledge in military matters and geography. One notable member was Edward Wright, one of the most accomplished geographers of the early seventeenth century who became Henry's mathematics and cosmography tutor. For Henry's education in astronomical mathematics, Wright designed

> a large sphere…for his Highness, by the help of some German workmen; which sphere by means of spring-work not only represented the whole motion of the

[208] Lesley B. Cormack, "Twisting the Lion's Tail: Practice and Theory at the Court of Prince Henry of Wales," 71.
[209] Quoted in Peter E. McCollough, *Sermons at Court: Politics and Religion in Elizabethan and Jacobean Preaching* (Cambridge: Cambridge University Press, 1995), 191.
[210] Quoted in Pauline Croft, ed., *Patronage, Culture, and Power: The Early Cecils* (Cambridge: Yale University Press, 2002), ix. See also Pumfrey and Dawbarn, "Science and Patronage in England," 181 n.57.

> celestial sphere, but shewed likewise the particular systems of the Sun and Moon, and their circular motions, together with their places, and possibilities of eclipsing each other. In it was a work by wheel and pinion, for a motion of 171000 years, if the sphere could be kept so long in motion.[211]

Wright was involved in both theoretical scientific pursuits as well as practical—his work *Certaine Errors in Navigation* explained the mathematical basis for the Mercator cartographic projection for the first time, but he also spent much of his time designing mathematical instruments, such as Henry's celestial sphere. Henry's penchant for patronizing practical, mathematical sciences in particular arose from a developing notion of English patriotism as England began to take its place on the international stage, both on the continent and in overseas colonies, during the early seventeenth century. Much as previous noble patrons of the sixteenth century had emphasized pragmatic scientific knowledge as a way to advance their careers and increase their wealth, James I and his son Henry applied this to a national scale, hoping to use the same type of knowledge to benefit the state as a whole against its European enemies.[212] Like many earlier patrons, Henry hoped to make the "more esoteric studies of astronomy and mathematics" more accessible and more useful to the English in service of their country.[213]

Much as Thomas Digges's and John Blagrave's experiences with patrons exemplified the control a patron's interests exerted over what their client-scientists

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[211] Thomas Birch, *The Life of Henry, Prince of Wales, Eldest Son of James I* (London, 1760), 389, quoted in Lesley B. Cormack, "Twisting the Lion's Tail: Practice and Theory at the Court of Prince Henry of Wales," 75.

[212] Lesley B. Cormack, "Twisting the Lion's Tail: Practice and Theory at the Court of Prince Henry of Wales," 67. See also Harkness, *The Jewel House*, 155-60, and Christopher Hill, *The Intellectual Origins of the English Revolution Revisited*, 213-19. Hill argues that Henry's interest in patronizing the sciences emerged out of his ardent Protestantism and his vehement anti-Catholicism. He claims that Henry hoped to promote the pragmatism of Protestantism through the pragmatism of science. Cormack concurs with Hill that Henry's religion likely played a role in his patronization, but counters that Henry's desire to see a strong England was more important.

[213] Cormack, "Twisting the Lion's Tail: Practice and Theory at the Court of Prince Henry of Wales," 67.

studied, the example of Thomas Harriot epitomizes how the changing fortunes of patrons had correlative effects on their client-scientists. Harriot attended Oxford from 1577 to 1580, and immediately upon his graduation he became attached to the court of Sir Walter Raleigh, then a favorite courtier of Elizabeth I, as his mathematics tutor.[214] Raleigh employed Harriot in a variety of capacities as a mathematician, but Harriot's most important role in the Raleigh household was as principal advisor for Raleigh's overseas ventures. Navigation was the greatest common interest between Harriot and Raleigh, and Harriot brought his extensive knowledge of mathematics to bear on practical issues regarding navigation, ship design, and the financial management of Raleigh's burgeoning colonial enterprises.[215] Under Raleigh's patronage, Harriot made a voyage to the coasts of present-day Virginia and North Carolina in 1585-6, where he acted as navigator for Raleigh's captains, surveyed and mapped the lands they encountered, and acted as a liaison between the English explorers and the Algonquians they met.[216] Harriot had learned at least some of the Algonquian language while in London through contact with two Algonquians living there—Manteo and Wanchese—and he translated for the English and transcribed much of the language during the voyage.[217] The expedition resulted in brief fame for Harriot after the publication of his *Briefe and True Report of the New Found Land of Virginia*, the only work published during his lifetime, which detailed the geography and material resources of coastal Virginia and gave general descriptions of the lifestyle and customs of the native Algonquians. Dedicated to Raleigh, this work

[214] Shirley, *Thomas Harriot: A Biography*, 70.
[215] Pumfrey and Dawbarn, "Science and Patronage in England," 162.
[216] Ibid.
[217] Shirley, *Thomas Harriot: A Biography*, 103-112.

essentially served as propaganda for Raleigh's own efforts to secure funding for his colonial ambitions, and with Raleigh's fortunes on the rise throughout the 1580s, Harriot's own star rose as well.[218] The fact that Harriot's *Briefe and True Report* remained his only published work reflects how utilitarian Raleigh's patronage was and mirrors the experiences of Digges and Blagrave.

By the late 1580s, Harriot had cultivated a new patronage contact with one of Raleigh's associate courtiers Henry Percy, the Earl of Northumberland. Northumberland began as an outsider to the Elizabethan court. Though he was a Protestant, he came from a Catholic family near the border with Scotland, a fact that would later briefly put him in the good graces of James I, but under Elizabeth, he was always at risk of being suspect for his religious and national affiliations.[219] Northumberland had great interest in the "mathematical magic" of astronomy and astrology, and during the last two decades of the sixteenth century, he assembled a court of scholars well-versed in many related sciences. The courtier circles of Raleigh and Northumberland overlapped with many client-scientists, including Harriot, who received his main income from Northumberland by the early 1590s.[220] Northumberland, often known as "the wizard earl" because of his enthusiastic interest in astrology, alchemy, and scientific experimentation, patronized some of the most accomplished and well-known scientists and natural philosophers of the 1590s, including the mathematicians Robert Hues and Walter Warner, who, along with

[218] Pumfrey and Dawbarn, "Science and Patronage in England," 163.
[219] Ibid.
[220] Ibid.

Harriot, were sometimes referred to as Northumberland's "three Magi."[221] Northumberland's interest in astrology can also easily be ascertained from the books that his client-scientists dedicated to him. Of the three that survive, two—Auger Ferrier's *Learned Astronomical Discourse, of the Iudgement of Nativities* (1593) and John Ford's *The Golden Mean…Discoursing of the Nobleness of Perfect Virtue in Extreames* (1614)—were about astrology and numerology, respectively.[222] While Harriot's interests gravitated toward the practical while he was in the employ of Raleigh, they moved in the direction of theoretical speculation once Northumberland became his chief patron.

During the 1590s and 1600s, Harriot's fate became inextricably tied to these two patrons, and their successive disgraces marred his otherwise successful scientific career. In 1591, Sir Walter Raleigh secretly married Elizabeth Throckmorton, one of Queen Elizabeth's ladies-in-waiting, without the queen's permission, and when the queen discovered this, she had Raleigh arrested and Throckmorton dismissed from her court.[223] Raleigh was briefly imprisoned in the Tower of London for these missteps and it took him several years to regain his courtly prestige and the support of Elizabeth. With Elizabeth's death and the ascension of James I, Raleigh's fortunes, and thus Harriot's, quickly took a downward turn. Less than a year into James's reign, in November 1603, Raleigh was once again arrested, this time for his connection to individuals involved in the Main Plot against the new king. This plot was concocted by several English Catholics who hoped to remove James from the throne and replace him with his Spanish cousin

[221] Shirley, *Thomas Harriot: A Biography*, 358-60.
[222] Pumfrey and Dawbarn, Science and patronage in England," 183 n.87.
[223] Shirley, *Thomas Harriot: A Biography*, 177-8.

Arbella Stuart, briefly considered a contender for the English throne during Elizabeth's last years.[224] Although Raleigh had no direct involvement in the plot, his close association with two people who were involved led to accusations of treason. He was found guilty, but his sentence of execution was commuted by James I, and Raleigh was imprisoned in the Tower once more, this time until 1616. His release was short-lived though, and after an expedition to Venezuela in which he harassed coastal Spanish forts, the Spanish ambassador to England successfully convinced James I to reinstate the death penalty. Raleigh was beheaded in 1618.[225]

Harriot's other patron fell out of favor with the Jacobean court for similar reasons. Sir Thomas Percy, a Catholic and cousin of the Earl of Northumberland, participated in the more notable Gunpowder Plot against King James on 5 November, 1605. After the plot was uncovered and thwarted shortly before being carried out, Percy fled London before being tracked down and killed by a marksman five days later.[226] Much like Raleigh's situation two years earlier, Northumberland had no direct involvement in the plot, but he was suspected of a having a connection to it through his cousin. He was fined £30,000 and imprisoned in the Tower of London for seventeen years.[227]

At the time of Northumberland's incarceration, Harriot relied almost entirely on Northumberland for his financial well-being and Northumberland's fall resulted in momentary disaster for Harriot. He was arrested as well, had his house and all his

[224] Ibid., 304-5.
[225] Ibid., 443.
[226] Ibid., 327-30.
[227] Ibid., 350-1. See also Christopher Lee, *1603: The Death of Queen Elizabeth, the Return of the Black Plague, the Rise of Shakespeare, Piracy, and Witchcraft, and the Birth of the Stuart Era* (New York: St. Martin's Press, 2003), 71-115.

scientific papers searched for wrongdoing, and was suspected by royal authorities of having cast James I's horoscope for Northumberland.[228] Harriot addressed James's Privy Council to plead his innocence, claiming that he "was never any busy medler in matters of state…never ambitious for preferments…but contented with a private life for the love of learning that [he] might study freely."[229] Harriot was released after a short stay in the Tower and he got his wish to "study freely," though unfortunately for him, this meant that he was severed from both his patrons and reduced to an annual pension of £100. He never published again, never developed any new relationships with any other potential patrons, and spent the remainder of his years quietly carrying out research in Copernican astronomy, atomic theories of matter, and theories of light.[230] A year after his release from the Tower, Harriot carried on a correspondence with Johannes Kepler, who wrote that he had been "informed that misfortune came to you from astrology. I ask you if you believe that it could be powerful enough to have such power."[231] It is unclear whether, by astrology, Kepler meant Harriot's practice of astrology or the stars' ill-effects on him.

Harriot's marginal status as an English scientific figure who exerted virtually no influence over the scientific community after 1605 directly reflected the marginal status of his patrons. Unlike most other courtier patrons of the Elizabethan and Jacobean eras, Northumberland seems to have been mostly uninterested in the practical scientific concerns that many of peers considered paramount. After moving from Raleigh to

[228] Pumfrey and Dawbarn, "Science and patronage in England," 163.
[229] Quoted in Pumfrey and Dawbarn, Science and patronage in England," 163.
[230] Ibid., 164.
[231] Letter from Johannes Kepler to Thomas Harriot, 1606, quoted in Edward Rosen, "Kepler's Attitude toward Astrology and Mysticism," in *Occult and Scientific Mentalities in the Renaissance*, ed. Brian Vickers (Cambridge: Cambridge University Press, 1984), 267.

Northumberland in the 1590s, almost all of Harriot's scientific interests revolved around theoretical matters as well, including astrology. Northumberland's ostentatious patronage style put him out of step with the largely utilitarian style of his fellow courtiers, and Harriot's negligible influence among scientists was likely among the consequences of this fact.

In the sixteenth century, practical concerns motivated English astronomer-astrologers to adopt Copernican mathematics to solve problems of planetary positions that the Ptolemaic system could not. These same motives caused them to use this mathematics in service of astrology. The interests of client-scientists typically aligned with those of their patrons, and so long as patrons demonstrated a utilitarian interest in mathematical, scientific astrology, then their client-scientists practiced this form of astrology by using the most innovative, precise mathematics. During the late sixteenth and early seventeenth centuries, these were the ephemerides, star charts, and calculations derived from Copernicus. However, the status of these client-scientists remained directly linked to that of their patrons, and if patrons lost interest in mathematical astrology—as happed to Digges and Blagrave—then financial support slowly vanished from these endeavors. If patrons ran afoul of authorities—such as Raleigh and Northumberland—then their client-scientists were forced to seek support elsewhere or withdraw entirely from active scientific research. However, as courts ceased to be the center of scientific activity throughout the middle of the seventeenth century, astrology moved to other institutional arenas that wanted something different from astrology and changed based on the needs of these new institutions.

CHAPTER FOUR

REDEFINGING ASTROLOGY IN THE SEVENTEENTH CENTURY: UNIVERSITIES, ALMANACS, AND JACOBEAN PATRONAGE

During the Jacobean era, the dominant location for scientific research and writing, including astrology, had been the royal court and the satellite courts of the nobility. However, during the mid-seventeenth century, the courts ceased to be the center of scientific activity, including mathematical astrology. Therefore, astrologers moved to other institutional venues and sought funding in different ways. The seventeenth century also witnessed a sharp increase in literacy, particularly among the rising merchant classes, and an explosion in astrological almanacs, pamphlets, and calendars, many of which relied less on claims to scientific legitimacy and more on the ability to appeal to a wider public. As astrology gained esteem among the popular classes, it began to wane in influence among the scientific community, particularly following the Civil War and the creation of the Royal Society in 1660. Astrology became re-categorized and redefined as something other than a science by the very group of English scientists who, for more than a century, had supported it. The mathematical practice of astrology disappeared, in part, because mathematicians no longer wished to associate with a field that increasingly sought mass appeal partially on the basis of excluding technical, mathematical detail. For decades, astrology had been rejected primarily on moral or religious grounds and critiqued scientifically by those who believed in it and wished to reform it. Beginning in the mid-seventeenth century, it was rejected for scientific reasons.

As we have seen, this dismissal of astrology had little to do with the impact of Copernicanism but had much more to do with how scientists attempted to define their practice and where they received their support. As patrons ceased to support astrologers in the numbers seen in the sixteenth and early seventeenth centuries, astrologers were forced to find new institutional settings within which to operate. Thus, while astrology gained in popularity among the popular classes through almanacs and pamphlets, the English scientific community consciously distanced itself from practicing astrologers as science simultaneously became a more professionalized discipline.

Although the courts were the locus of major scientific activity in the early seventeenth century, many of the client-scientists patronized by the nation's nobility had attended university and had become well-versed in the traditional curriculum of Latin grammar and rhetoric, mathematics, and Aristotelian physics and astronomy. Although universities remained highly traditional establishments offering programs in the seven liberal arts, they still served as the primary training ground for young scholars eventually hoping to become attached to the courts. While a university education had been desirable but not required in the early sixteenth century, by the seventeenth century it became essential for inclusion in royal courts. A university education not only carried cultural and intellectual prestige but also prepared future client-scientists for scientific research at court. For example, a clear majority of practicing client-scientists at the court of Prince Henry, James I's son, held university degrees, and the more technical their interests, the more likely they were to have received one.[232] Of the thirty-seven mathematicians,

[232] Cormack, "Twisting the Lion's Tail: Practice and Theory at the Court of Prince Henry of Wales," 72.

astronomer-astrologers, geographers, and cartographers at Henry's court, twenty-five had received a Bachelor of Arts degree and all but two received them from either Oxford or Cambridge.[233] This suggests both the rise in the importance of a university education and also the degree to which this education had become a national affair. The universities and the courts became more closely linked beginning as early as the mid-sixteenth century and this relationship expanded throughout the early seventeenth. The chancellorship of both Oxford and Cambridge belonged to major nobles during both the Elizabethan and Jacobean eras— Robert Dudley, Earl of Leicester, a notable astrological enthusiast, held the chancellorship of Oxford from 1564 until his death in 1588, and William Cecil, Lord Burghley, held the chancellorship of Cambridge from 1560 until his death in 1598.[234] Burghley's son Robert Cecil, Early of Salisbury, a major patron of the sciences, would go on to be the Chancellor of Cambridge from 1601 to 1612.[235] The chancellorship of both universities throughout the reign of James I remained firmly in the hands of nobles who patronized the arts and sciences.

The universities, however, remained locations for a traditional knowledge-base with content derived from classical antiquity and teaching and learning methodology derived from high medieval Scholasticism.[236] The original intention of the medieval Scholastic system was to employ dialectical reason and logic in order to resolve contradictions between Aristotelian philosophy and Christian theology. Typically, a university professor revealed the contradictions between two sources of knowledge,

[233] Ibid., 72-3. Cormack notes that the two who did not attend either Oxford or Cambridge attended Leiden University in the Dutch Republic. Neither was English.
[234] Pumfrey and Dawbarn, "Science and Patronage in England," 150-1.
[235] Ibid.
[236] Costello, *The Scholastic Curriculum at Early Seventeenth Century Cambridge*, 7-35.

argued them from both sides, and proposed a resolution. A normal class included a *lectio* ("lecture," or more precisely "reading"), in which a professor read verbatim from an important text—usually Scripture, Aristotle, the writings of the Church fathers, or recent commentary on these—and occasionally supplemented this with his own remarks.[237] Alternatively, professors used the *disputatio*, or *quaestio disputatio* ("discussion of a question"), where they would answer questions proposed by students beforehand using Aristotelian logic to come to their conclusions.[238] These methods emerged out of the early university system of the twelfth and thirteenth centuries and were generally still considered standard as late as the early seventeenth century. The university curriculum followed the trivium of Latin grammar and rhetoric along with logic, and the quadrivium of astronomy, music, arithmetic, and geometry. More advanced students often went on to study medicine, law, or theology.[239] Although new insights into natural philosophy often found their way into the traditional curriculum, they remained ancillary to the established liberal arts.

Even though they were enthusiastic patrons of the sciences at court, both Queen Elizabeth I and King James I maintained the status quo in the universities. In 1588, upon receiving a petition for a reform in the curriculum at St. John's College, Cambridge,

[237] Hollister and Bennett, *Medieval Europe: A Short History*, 312. See also Sten Ebbesen, "Ancient Logic as the Source for Medieval Scholastic Logic", in *The Cambridge History for Later Medieval Philosophy: From the Rediscovery of Aristotle to the Disintegration of Scholasticism, 1100-1600*, eds. Norman Kretzmann, Anthony Kenny, and Jan Pinborg (Cambridge: Cambridge University Press, 1982), 101-127; and Costello, *The Scholastic Curriculum at Early Seventeenth Century Cambridge*, 10-11.
[238] Costello, *The Scholastic Curriculum at Early Seventeenth Century Cambridge*, 11. An alternate version of this method was known as the *quodlibet* (literally, "to do as one pleases," but used to mean "question at random") in which the question was not known beforehand, and the professor would answer the question on an *ad hoc* basis. The *disputatio* followed a particular structure of *quaestio, responsio, et determinatio* ("question, response, and conclusion"), while the *quodlibet* was less structured.
[239] Ibid., 10.

Elizabethan lawmakers reinforced the traditional Scholastic system, calling it "best…for the increase of learning, for the greater good of youth, for the state and benefit of the College."[240] Similarly, in 1601, newly appointed Chancellor Robert Cecil, Earl of Salisbury, specified that the Scholastic "Lectures and Disputations" be maintained, and that "all dueties and exercises of learninge be diligently and duely performed accordinge to the Statutes & Orders of the Universitie."[241] James I explicitly supported the traditional Scholastic system in 1619 by commanding that "no new erected Lectures…be permitted to withdrawe Scholars from their attendance on the exercises of Learning, Lectures, Disputations, Determinations, or Declarations, either publique or private."[242] While they remained open to a variety of experimental and unconventional approaches to knowledge acquisition at court, royal authorities and the nobility remained resistant to change in the institutional university. This not only suggests that royal authorities desired to maintain control of how knowledge was disseminated and received but also that they viewed the type of knowledge attained at universities and practiced at court as two separate enterprises. Presumably, universities provided a stable and standardized curriculum and methodology that, by its very unchanging nature, ensured that all future scholars would be familiar with the same body of knowledge and the same procedures of logical argumentation. At court, however, this methodology was frequently flouted in favor more empirical methods.

[240] Baker manuscript, 77, University of Cambridge Library, quoted in Costello, *The Scholastic Curriculum at Early Seventeenth Century Cambridge*, 8.
[241] Ibid, 27.
[242] Charles H. Hooper, *Annals of Cambridge*, Vol. 3 (Cambridge, 1842-53), 130, quoted in Costello, *The Scholastic Curriculum at Early Seventeenth Century Cambridge*, 8.

All manner of non-traditional scholars found homes at courts where they were offered some degree of protection from the more conservative churches and universities, where their work would have been seriously stifled. Significantly, all pre-Galilean Copernicans in England worked outside of Oxford and Cambridge and depended on patronage for their financial support, while the curriculum at both of those universities continued to emphasize the Ptolemaic system well into the seventeenth century.[243] In fact, although well-known astronomers such as Everard Digby, William Temple, and Gabriel Harvey had begun to harshly criticize Aristotle at Cambridge as early as the 1560s, there is no evidence than any Copernican held any prominent position there until several decades into the seventeenth century.[244]

During the late sixteenth and early seventeenth centuries, the position of astrology also reflected the importance of the court system in the advancement of knowledge and its obvious differences from the university system. As early as the 1570s, Oxford and Cambridge professors were delivering lectures critical of judicial astrology, and in 1619, Oxford's Savilian professor of astronomy was banned from teaching any astrology altogether, demonstrating not only the conservative nature of the universities but also the degree to which astrology had declined in intellectual respectability among some scientists.[245] Astronomy and mathematics, two separate branches of study under the quadrivium of the seven liberal arts, rarely overlapped in their traditional study, but since

[243] Ibid., 144; Capp, *English Almanacs*, 199.
[244] Russell, "The Copernican System in Great Britain," 201.
[245] Thomas, *Religion and the Decline of Magic*, 351. See also Rutkin, "Astrology," in *The Cambridge History of Science: Early Modern Science*, 553; and Mordechai Feingold, "Occult Traditions in the English Universities," in *Occult and Scientific Mentalities in the Renaissance*, ed. Brian Vickers (Cambridge: Cambridge University Press, 1984), 74

at least Copernicus, they had begun to coalesce more and more.[246] A growing number of astrological skeptics in the scientific community consciously rejected the application of mathematics to astrology just as they applied mathematics more readily to the increasingly distinct science of astronomy.[247] By 1649, the astrologer Jeremiah Shakerly was able to write to his mentor William Lilly that he "often wish[ed] a nearer affinity between the two Arts of Astronomie & Astrologie," noting that by then, they had separated, and astronomy had gained the higher ground as mathematical science.[248]

During the sixteenth and early seventeenth centuries, the patronage system allowed for much freer thinking and allowed scholars to explore much more unorthodox topics than was possible at universities. The courts fostered a form of "post-scholastic" knowledge built on the foundation of a university education (since, by the early seventeenth century, most client-scientists at court had received one). Court client-scientists oftentimes diverged from the university knowledge-base precisely because the research that they performed under the auspices of the court system contradicted what they learned at university.[249] While English patrons often required empirical evidence to validate their financial support, universities required only adherence to the Scholastic method and logical argument. The Scottish writer John Barclay, who moved to England shortly after James's ascension to the throne, singled out client-scientists at the English court for their willingness to oppose Aristotle and Ptolemy in the realm of cosmology, writing that "in philosophy and mathematics, in geography and astronomy, there is no

[246] Rutkin, "Astrology," in *The Cambridge History of Science: Early Modern Science*, 553-4.
[247] Ibid.
[248] Letter from Jeremiah Shakerly to William Lilly, 28 April 1649, quoted in Bowden, *The Scientific Revolution in Astrology*, 43.
[249] Pumfrey and Dawbarn, "Science and Patronage in England," 141-44.

opinion so prodigious and strange, but in that island was either invented, or has found followers and subtile instancers."[250] More importantly, patrons' demands for empirical, observational, and experimental evidence meant that methodology based on logical proofs and argumentation faded in importance in the courts more rapidly than in the universities.

This formula for arriving at knowledge and evaluating evidence found its most fervent proponent in the works of Francis Bacon. Bacon's emphasis on empirical methodology greatly impacted Scientific Revolution-era natural philosophers, particularly in England. His major work on the topic, the *Novum Organon* of 1620, systematically presented his argument against Aristotelian syllogistic logic and for a form of inductive reasoning based on empirical evaluation of evidence. The very name *Novum Organon* evoked Aristotle's *Organon*, the compiled body of Aristotle's six works on logic, which Bacon hoped to invalidate. Bacon's criticism of Aristotelian logic, "which served rather to fix and give stability to errors…than to help the search after truth" was also a direct criticism of the Scholastic methods of the universities, which rested on the foundations of Aristotelian logic.[251] Bacon stressed that scientists "can do and understand so much and so much only as [they] have observed in fact…of the course of nature" and that "our only true hope lies in induction."[252] By linking observation, empiricism, and induction, Bacon promoted a set of techniques that allowed seventeenth-century scientists to standardize and homogenize their practice. Furthermore, Bacon also recognized that by

[250] John Barclay, *Icon Animorum* (London, 1614), from *The Mirrour of Mindes*, trans. T. May 1631, quoted in Christopher Hill, *The Intellectual Origins of the English Revolution Revisited*, 59.
[251] Francis Bacon, *The New Organon* [1620], ed. and trans. Fulton H. Anderson (Indianapolis: Bobbs-Merrill Educational Publishing, 1960), 41.
[252] Ibid., 39 and 41.

discovering and better understanding the laws of nature, scientists could better control nature. In the oft quoted passage describing "human power and human knowledge meet[ing] in one," Bacon instructed that "where a cause is not known an effect cannot be produced—nature to be commanded must be obeyed."[253] According to Bacon, scientists could not control nature without first understanding natural laws.

Bacon, at least in part, had astrology in mind when he wrote this. Three years after the *Novum Organon*, Bacon wrote *De Augmentis Scientarum*, which further expounded upon his program of empiricism and inductive reasoning through pithy aphorisms that commented on many areas of human knowledge, astrology among them.[254] Bacon's view of astrology was much like that of Kepler and other reformers who recognized that if astrology were to be considered a valid science, it must be subjected to scientific methodology. "As for Astrology," Bacon wrote, "it is so full of superstition, that scarcely anything sound can be discovered in it. Notwithstanding, I would rather have it purified than rejected altogether."[255] Bacon's directions for reform, however, were prescriptive and programmatic and laid out a methodological system which he hoped astrologers would use in order to reform their science. He merely opened the door—he asked practicing astrologers to walk through it.

Bacon's new methodological thinking influenced mathematical astrologers for a time. For example, the astrologer Jeremiah Shakerley wrote, "Why then shall we subject

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[253] Ibid., 39

[254] Catherine Drinker Bowen, *Francis Bacon: The Temper of a Man* (Boston: Little, Brown, and Co., 1963), 146 and 150.

[255] Francis Bacon, *De Augmentis Scientarum* [1623], Book 3, Chapter 4, in *The Works of Francis Bacon*, Vol. 8, eds. James Spedding Robert Leslie Ellis, and Douglas Dennon Heath, 15 vols. (Boston: Brown and Taggard, 1861), 489, quoted in Bowden, *The Scientific Revolution in Astrology*, 164.

ourselves to the authority of the Ancients, when our own experience can inform us better?"[256] Similarly, the astrologer Joshua Childrey, who was also a telescopic observer of the heavens, remarked that heliocentrism had been demonstrated "*ad oculum*," or "by sight," and commented that it made no more scientific sense to continue to practice astrology under the Ptolemaic system.[257] In fact, those who attempted a Baconian reform practiced what some contemporaries referred to as *astrologia sana*, or "sane astrology."[258] However, Bacon's request for an empirically-based astrology was a double-edged sword. On the one hand, as with the mathematical reforms attempted by scientists since the time of Pico della Mirandola and Copernicus, a further reform employing the Baconian inductive method allowed judicial astrologers to claim more ground as legitimate scientific practitioners. On the other hand, astrologers were ultimately addressing problems that had no solutions and the increased application of empiricism to astrology only further revealed its scientific inadequacies.

It was during the second half of the seventeenth century that the decline of astrology as a legitimate scientific practice became clear. As we have seen, Copernicanism in general did not have any ill-effects on the practice of astrology, and for those astrologer-astronomers mathematically savvy enough to recognize its advantages and appropriate its methods for the benefit of astrology, Copernicanism actually solved some of the problems of astrology. What contributed to the downfall of astrology in the scientific community? The principal complaints against astrology from its detractors had

[256] Quoted in Richard Foster Jones, *Ancients and Moderns: A Study of the Rise of the Scientific Movement in Seventeenth Century England* (New York: Dover Publications, 1982), 123.
[257] Bowden, *The Scientific Revolution in Astrology*, 170. *Ad oculum* literally means "to the eye."
[258] Rutkin, "Astrology," in *The Cambridge History of Science: Early Modern Science*, 558 and Bowden, *The Scientific Revolution in Astrology*, 166.

been largely political and religious—the scientific complaints against it were typically made by those who wished, not to destroy it, but to reform it. But by the second half of the seventeenth century, it began to be ridiculed scientifically as well. Far more damaging for astrology than the Copernican theory was the discovery of more astronomical bodies, beginning with the Galilean moons of Jupiter in 1610. While not explicitly contradictory to the tenets of astrology, the existence of more heavenly bodies suggested to many that all prior astrological literature was flawed because it did not, indeed *could not*, take into account the influence of these moons.[259]

More complications arose with increased European travel to the southern hemisphere. Throughout the sixteenth and seventeenth centuries, and particularly following the defeat of the Spanish Armada in 1588, English voyages to the New World and to locations south of the equator rose dramatically as the English joined the Spanish, Portuguese, Dutch, and French in overseas exploration. Astrological critics noted that with an entirely new set of stars up until then unseen and unknown by Europeans, an entire new set of rules would be required to explain the effects of the stars and planets on people living in these locations.[260] Furthermore, the locations of the planets, sun, and moon were in different constellations during different seasons in the southern hemisphere, and these could not be reconciled with the way astrology had been practiced from the time of Ptolemy to the early modern era without serious revision. For example, in his *Tetrabiblos*, Ptolemy had designated Leo "the sign of the sun" because the sun was

[259] Bowden, *The Scientific Revolution in Astrology*, 115-6. See also Keith Thomas, *Religion and the Decline of Magic*, 349-352.
[260] Bowden, *The Scientific Revolution in Astrology*, 80.

in the constellation Leo during the warmest time of the year from late July to late August. Critics argued that in the southern hemisphere this should be reversed, and Aquarius should be designated the sign of the sun.[261] Both detractors of astrology such as Pico della Mirandola and reformers such as John Dee recognized this.

The idea of the infinity of the universe and the ever expanding catalogue of stars also complicated astrological practice. The idea of an infinite universe, proposed by Western astronomer-astrologers such as Nicholas of Cusa and Marcellus Palingenius, dated back as far as the mid-fifteenth century.[262] Noted pre-Galilean Copernicans and adherents to judicial astrology Thomas Digges and Giordano Bruno both posited a sun-centered universe with an infinite number of stars extending into infinite space. The introduction of even more heavenly bodies—from the Galilean moons of Jupiter to the increasingly abundant stars discovered with the help of the telescope—merely multiplied the complexity. Among reformist astrologers, the effects of the heavens on human events could be determined through closer observation of the heavens and more precise measurements of the movements of the stars and planets, but this became significantly more difficult as the objects in the heavens seemed to increase exponentially.[263]

This difficulty had been taken up by both John Dee and Thomas Digges in the mid-sixteenth century. Though he had maintained the Ptolemaic notion of a sphere of fixed stars, Dee had admitted a similar problem when attempting to discern the means by which heavenly bodies exerted an influence over the earth. According to Dee, the

[261] Ibid.
[262] Alexandre Koyré, *From the Closed World to Infinite Universe* (Baltimore: The Johns Hopkins University Press, 1957), 5-57.
[263] Bernard Capp, *English Almanacs*, 198.

astrological influences of the stars and planets were carried in the light they emitted. This light emerged and formed a cone in which the planet or star of origin marked the vertex and the surface of earth touched by this light marked it base. The *further* away a planet or star was from the earth, argued Dee, the more surface area it illuminated, and thus, the *greater* power it had to affect human events.[264] If Digges followed Dee's interpretation of the power of stars as inversely proportional to their distance from the earth, which is quite possible given their former professional relationship, then Digges's new model of an infinite Copernican cosmos created even more complexities for reformist astrologers.[265] On the one hand, the stars now stood at a much greater distance from the earth than they had with Copernicus's sphere of fixed stars, meaning that their influence on the earth was even greater. On the other hand, if every individual star stood at varying distances from the earth, then it made precise measurement all but impossible for reformist astrologers. Unfortunately, Digges left no record of having directly adapted his astrology to this cosmological structure.

Astronomer-astrologers in England had not yet resolved this problem by the early seventeenth century. In fact, amidst the accumulation of new stars and moons discovered about the planets, many astronomer-astrologers consciously limited the number of stars they accepted as important for complete knowledge of their astrological effects. Just days after Galileo's publication of *Sidericus Nuncius* in 1610—which announced his

[264] Bowden, *The Scientific Revolution in Astrology*, 68-69 and 92-93 nn.20-22. See also French, *John Dee*, 92-96. Bowden argues that Dee likely barrowed the idea of combining optics and astrology from Roger Bacon, who had mentioned similar ideas in his *Opus Majus*, particularly Book 4, Chapters 3 and 4. Dee expounded upon this idea in his *Propaedeumata*, which adhered the Ptolemaic system. See also, Thomas Digges, *A Prognostication Everlastinge*, 110.

[265] Bowden, *The Scientific Revolution in Astrology* , 68 and Johnston, "Like Father, Like Son? John Dee, Thomas Digges, and the Identity of the Mathematician," 73-74.

discoveries of mountains and valleys on the moon, the phases of Venus, and moons circling Jupiter—Henry Wotton wrote to Robert Cecil, Earl of Salisbury, that "upon the whole subject, he [Galileo] hath overthrown all former astronomy…and next all astrology. For the virtue of these new planets must needs vary the judicial part, and why may there not yet be more."[266] In 1624, astrologer and almanac publisher George Hawkins wrote that the amount of stars astrologers should regard as relevant for use in prognostications "should be limited to 1,025 stars and no more" since astronomers and astrologers should not be expected to "take account of every little star."[267] Significantly, the figure of 1,025 was derived from Ptolemy's star catalogue, which counted 1,028 stars, while admitting the possibility that there were more.[268] Just four years later in 1628, almanac-writer Eustace Clarke, a Copernican, wrote of many more stars, claiming that

> The number of fixed Starres is commonly defined as 1725, although their exact number cannot indeed be exactly limited, being almost infinite as the Astronomers do descrie, by an help of the hollow instrument of the invention of Galilaeus: By said instrument, Venus is discerned with the eie, increasing and decreasing as the moon. Saturne is seen having three bodies [i.e., rings]; Jupiter having four other Starres moving with him for his attending guard. Likewise the Sunne himselfe appeareth diversely spotted as the Moon…[269]

Both the addition of known stars augmented by the observations of Tycho Brahe and the discovery of new celestial bodies by Galileo seriously brought into question judicial astrology as it was practiced in the mid-seventeenth century.

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[266] Letter from Sir Henry Wotton to Robert Cecil, Earl of Salisbury, 13 March 1610, in *The Portable Elizabethan Reader*, ed. Hiram Haydn, 145.
[267] George Hawkins, *An Almanac and Prognostication* (London, 1624), sig. B, quoted in Bernard Capp, *English Almanacs*, 198.
[268] Bernard Capp, *English Almanacs*, 427 n.114.
[269] Eustace Clarke, *A New Almanack for…1629* (Cambridge: Printers of the University, 1628), sig. B5*v*-B6*r*, quoted in Johnson, *Astronomical Thought in Renaissance England*, 257.

While mathematical astrology found difficulties among both its critics and reformers, popular texts flourished among the increasingly literate populace of England, whose access to astrology was facilitated primarily through the publication of almanacs and short tracts on its practice. Almanacs helped to popularize Copernican astronomy as well as astrology, particularly in the first half of the seventeenth century, and the focus of many almanacs on applied astrology meant that in many cases, expositions of the Copernican theory and astrology went hand in hand, usually in non-mathematical ways. In fact, most people educated enough to read pamphlets received most of their knowledge about astronomy, including the Copernican system, through astrological almanacs and manuals.[270]

Almanacs of the early seventeenth century marked a transitional period from the influence of scientific, mathematical astrology to the popularity of non-mathematical astrology. As we have seen from examples such as Leonard and Thomas Digges's *Prognostication Everlastinge*, almanacs often offered a variety of compendious information of astronomical, astrological, meteorological, or agricultural significance. Throughout the sixteenth and early seventeenth centuries, these were often highly technical manuals that employed complex mathematics, and many recommended the use of Copernican mathematics for astronomical and astrological calculations. However, while many popular astrologers of the mid-seventeenth century relied on the same

[270] Capp, *English Almanacs*, 191-214. See also Johnson, *Astronomical Thought in Renaissance England*, 248-287.

mathematical calculations as the astrological reformers, they ceased to emphasize these technical details in their almanacs.[271]

This transition occurred over several decades. For example, one of the most ardent Copernican astrologers and popular almanac publishers of the 1610s was Thomas Bretnor. A self-styled "professor of mathematicks and student of the physickes," Bretnor openly mocked those who refused to accept Copernicanism despite the mathematical and observational evidence, referring to the geocentric theory of Ptolemy as a "vulgar opinion" and an "old fantasie."[272] Bretnor often took note in his description of the movement of the heavenly bodies that when he wrote about the sun's movement, he meant not that it truly moved, but that it appeared to move relative to the earth:

> This Brumal season, commonly called *Winter*, and visually taken for the first quarter of our Astronomicall yeare, tooke its beginning the 11 or December last: for then (according to the old dotage [the geocentric theory]) did the Sun enter the first scruple of the cold and the melancholicke signe *Capricorne*, or rather according to the verity this earthy planet entering the first minute of *Cancer*, and furthest deflected from the Sunnes perpendicular raies, did then receiue least portion of Sunshine, and greatest quantitie of shadow.[273]

Later, Bretnor went on to change various descriptions in his own almanacs regarding the locations of the planets with relation to the constellations, for example, rewriting "the sun in Aries" as "the earth in Libra" to better conform to the Copernican cosmos.[274] His almanac, published annually from 1607 until 1635, consistently employed Copernican

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[271] Capp, *English Almanacs*, 190-204.

[272] Thomas Bretnor, *A Newe Almanacke and Prognostication for…1615* (London: Company of Stationers, 1614), sigs. B4*r*-C2*v*. http://eebo.chadwyck.com.echo.louisville.edu/search/full_rec?SOURCE=pgimages.cfg&ACTION=ByID&ID=99900493&FILE=../session/1303973193_20453&SEARCHSCREEN=CITATIONS&VID=173331&PAGENO=13&ZOOM=100&VIEWPORT=&SEARCHCONFIG=var_spell.cfg&DISPLAY=AUTHOR&HIGHLIGHT_KEYWORD=undefined. (accessed 28 April 2011). See also Johnson, *Astronomical Thought in Renaissance England*, 252-3.

[273] Ibid.

[274] Ibid., sig. C3*r*.

mathematics and mentioned Ptolemy or the geocentric system only to ridicule them. Similarly, the popular Copernican astrologer Joshua Childrey wrote in 1652 that all calculations regarding the positions of the planets should be made "with respect to the sun" rather than "with respect to the earth," as many still did.[275] Both Bretnor and Childrey advocated these changes out of a desire to see more precise calculations regarding the positions of the planets and more accurate predictions. However, these astrologers were among the last generation to emphasize mathematics or even Copernicanism in their almanacs as a means of promoting their own legitimacy. Seventeen years later, in 1669, Childrey wrote to Henry Oldenburg, secretary of the Royal Society, wondering "why in that Synopsis of…Sprats history [of the Royal Society], ye Aspects of ye Planets should be omitted."[276] Childrey lamented that astrologers were no longer interested in the systematic mathematical reform that had characterized the earlier century. Once readers assumed that astrologers' methods were scientific, their interests turned to their ability to correctly prognosticate future human events.

By the 1630s few almanac-makers or practicing astrologers adhered to the Ptolemaic system any longer, and the debate for the next two decades revolved around

[275] Joshua Childrey, *Indago Astrologica: or, A Brief and modest Enquiry into some Principal Points of Astrology As it was delivered by the Fathers of it, and is now generally received by the Sons of it* (London, 1652), 3. See also Bowden, *The Scientific Revolution in Astrology*, 170. http://eebo.chadwyck.com.echo.louisville.edu/search/full_rec?SOURCE=pgimages.cfg&ACTION=ByID&ID=99865889&FILE=../session/1303972766_19834&SEARCHSCREEN=CITATIONS&VID=118142&PAGENO=2&ZOOM=150&VIEWPORT=&SEARCHCONFIG=var_spell.cfg&DISPLAY=AUTHOR&HIGHLIGHT_KEYWORD=undefined. (accessed 28 April 2011). Childrey's Latin reads "*quoad universum, non quoad nos*," meaning literally "with respect to the universe, not with respect to us."

[276] Letter from Joshua Childrey to Henry Oldenburg (12 July 1669), *Correspondence*, VI, No. 1240, quoted in Bowden, *Scientific Revolution in Astrology*, 175.

the applicability of astrology to the Copernican and Tychonic systems. The Tychonic system, named after Tycho Brahe and sometimes referred to as the geoheliocentric theory, was a hybrid system that combined the mathematics of the Copernican system with the physical conception of the Ptolemaic system. In the Tychonic system, the sun and moon revolved around an immobile earth while the five planets revolved around the sun. Mathematically, it accounted for the motion of the heavenly bodies as precisely as the Copernican system, but unlike Copernicus, Tycho included many of his own observations of the heavens when he presented his theory.[277] Ironically, it was these very observations that eventually led Johannes Kepler, Tycho's former assistant, to the conclusion that the planetary orbits were elliptical rather than circular, thus negating the need for Tycho's system. "I confess that when Tycho died," Kepler later wrote, perhaps with some guilt, "I quickly took advantage of the absence, or lack of circumspection, of [Tycho's] heirs, by taking the observations under my care, or perhaps usurping them."[278] Though a Copernican, Kepler also based his Rudolphine Tables of 1627, which replaced the now-outdated Prutenic Tables of 1551, on Tycho's observations. By the 1650s, the Tychonic system had few adherents in the English astronomical or astrological communities.

Practicing popular astrologers, however, removed themselves from the mathematical and scientific debate. As late as the 1680s, the English astrologer and almanac-writer John Goad reassured his followers that astrology could operate under any cosmological framework and that if the debate between the Copernican and Tychonic

[277] Gingerich, *The Book Nobody Read*, 49.
[278] Quoted in Stephen Hawking, ed., *On the Shoulders of Giants*, 631.

systems "proves to be non-Conclusive, we must need averr, that our principle of Prognostic is unquestionable."[279] As patrons' interest in astrology declined, they employed fewer and fewer astrologers at court, and these astrologers often found themselves employed by the public at large, whose purchase of their almanacs constituted their primary income.[280] Ephemerides, those multi-year collections of planetary tables upon which astrologers had once heavily relied, ceased to contain their astrological components by the final third of the seventeenth century.[281] In the sixteenth and early seventeenth centuries, ephemerides often contained lengthy introductions describing their astrological uses, horoscopes, and tables specifically exhibiting the aspects, or the relative angles between two heavenly bodies. By the 1670s and 1680s, most ephemerides had dropped all explicit references to astrology. Correspondingly, by the turn of the eighteenth century, the complex mathematical demonstrations from the almanacs showing how to determine the positions of the planets oneself had almost entirely vanished, leaving only a non-mathematical description of the planets' aspects.[282] No longer preoccupied with justifying their practice through the latest mathematical and astronomical advances, the scientific reform of astrology subsided.

While evidence of this decline in mathematical astrology exists in the textual records of these ephemerides, its cultural origins date back to at least the 1640s and the coming of the English Civil War. On the eve of the war in 1642, the royal government

[279] John Goad, *Astrometeorologica* (London, 1686), 122-26, quoted in Bowden, *The Scientific Revolution in Astrology*, 184.
[280] Campion, *A History of Western Astrology*, 166-9.
[281] Rutkin, "Astrology," in *The Cambridge History of Science: Early Modern Science*, 554.
[282] Ibid. Rutkin examined mostly Italian almanacs and ephemerides, but he claims that ephemerides from "France, Germany, [and] England corroborate this picture." See 554 n.52.

exerted complete control over the legal status of astrology, and following the example of both the Elizabethan and Jacobean governments, Charles I allowed astrologers to practice and publish provided that they refrained from prognosticating anything negative about the royal government.[283] As late as 1641, a Jacobean law required that "all printers and booksellers" who publish "any prophecies or almanacs" must have them "seen or revized by the archbishop or bishop (or those who shall be expressly appointed for that purpose) and approved by their certificates, and, in addition, shall have permission from us or from our ordinary judges."[284] However, following the Long Parliament's defiance of Charles I's authority and the king's absconding from London in January 1642, the censorship system collapsed and the publication of pamphlets and almanacs increased exponentially.[285]

Before 1640, no printed newspapers existed in England; by 1645, there were over a hundred in print, and nearly all contained astrological predictions.[286] Similarly, pamphlets—short political tracts published cheaply, often with astrological overtones—multiplied as well. George Thomason, a mid-seventeenth century book collector, claimed to have collected only twenty-two astrological pamphlets in 1640, while he found nearly *two thousand* just two years later.[287] The Civil War contributed to a sort of pamphlet warfare between astrologers who were Parliamentarians and those who were Royalists, and political and religious concerns motivated pamphleteers and their consumers far

[283] Curry, *Prophecy and Power*, 19-22.
[284] Abel Heywood, *Three Papers on English Almanacs* (?London: Privately Published, 1904), 6, quoted in Curry, *Prophecy and Power*, 20.
[285] Curry, *Prophecy and Power*, 20-1. See also Hill, *Intellectual Origins of the English Revolution Revisited*, 100.
[286] Ibid., 19. See also Thomas, *Religion and the Decline of Magic*, 342.
[287] Ibid.

more than scientific ones. The uncertainty that accompanied the English Civil War and the Interregnum contributed to a drastic increase in what many contemporary scientists somewhat disparagingly called "vulgar astrology," while the execution of Charles I and the removal of his court from power in 1649 meant that the patron-client relationship that had fostered scientific and mathematical astrology for over a century had come to an end.[288]

By the time of the Restoration of the monarchy and the coronation of Charles II in 1660, astrology, as it was accepted in English society, had irrevocably changed. Despite the fact that the monarchy survived the Civil War and the nobility returned to court largely intact, the locus of scientific activity moved to a newfound institution, the Royal Society.[289] Founded in the very year of the Restoration, the Royal Society promoted the Baconian ideals of experimentalism and empiricism and provided English scientists with an official community within which to conduct research. Astrology was almost entirely absent from its records. Entire years went by without its mention, and when scientists did discuss it, they often did so negatively.[290] The lack of experimental demonstrability suggested to many scientists that, as anti-astrological writer Thomas Cooper contended, "the rules of this art have no foundation in experience."[291] By the late 1650s, according to the astrologer John Gadbury, students at both Oxford and Cambridge could not be

[288] Lynn Thorndike, *A History of Magic and Experimental Science: The Seventeenth Century,* Vol. VI (New York: Columbia University Press, 1958), 27.
[289] Campion, *A History of Western Astrology*, 164-8.
[290] Bowden, *The Scientific Revolution in Astrology*, 50-1.
[291] Quoted in Thomas, *Religion and the Decline of Magic*, 352.

bothered to study judicial astrology, "bawl[ing] loudly in the Schools" that "astrology is not a science."[292]

At the very same time, popular almanacs remained on the rise. At their height in the late 1650s, astrological pamphlets and almanacs accounted for as much as one third of all English book sales, and after the Bible, were reportedly the most widely read works in all of England.[293] The general populace did not require the type of utilitarian proof that patrons coveted in the sixteenth and early seventeenth century, nor did they insist on adherence to empirical or experimental methodology. Despite the fact that late seventeenth-century pamphleteers, almanac-makers, and common astrologers still practiced a form of astrology largely derived from the mathematical astrology of the previous century, they had no need to convince their primary customers—the English public—of the scientific efficacy of astrology. And as the scientific community consciously disassociated itself from the practice of astrology and redefined it as something outside the bounds of science, the new, popular astrological community embraced it as a lucrative practice that the English populace craved. Where once it was in the interest of scientists to legitimate astrology as a mathematical science, it became in their best professional interest to scorn it.

[292] Ibid., 353. "*…astrologia non est scientia*."
[293] Curry, *Prophecy and Power*, 21-2.

CONCLUSIONS

"The majority of that which is called superstition
is born from a mistaken application of mathematics."

–Johann Wolfgang von Goethe

"The question of all questions for humanity,
the problem which lies behind all others and
is more interesting than any of them,
is that of the determination of man's place
in nature and his relation to the cosmos."

– T.H. Huxley

Contrary to traditional historiography, the Copernican theory did not contribute to the demise of judicial astrology. In fact, among those reformers within the English patronage system who utilized Copernican mathematics to more precisely predict the motions of the planets, it actually strengthened its legitimacy. The reformist astrologers intent on making judicial astrology a more exact science appropriated new mathematical tables where they could. As patrons defined the value of science in terms of its practical utility, many English judicial astrologers successfully argued for scientific legitimacy based on their ability to precisely predict planetary locations. Provided that patrons persisted in considering this *modus operandi* practically useful, judicial astrologers continued to flourish within this system. However, while the positions of the stars and planets became increasingly predictable in post-Copernican astronomy, prognostication of human events did not.

The process of by which early modern scientists redefined and re-categorized knowledge about astrology occurred within the context of the Scientific Revolution. The utilization of observational techniques and experimentation, the employment of logically inductive reasoning, and the precise quantification of data all signified major transformations in the way scholars acquired knowledge about the physical world. Yet early modern scientists did not adopt these methodological characteristics all at once, nor did they all accord them equal legitimacy. Those early modern astrologer-astronomers who embraced these techniques quickly found themselves with much more precise data regarding the positions and motions of sun, moon, stars, and planets. Given these new defining characteristics of science and the technical problems besetting Ptolemaic observational astronomy, it is unsurprising that many early modern astrologer-astronomers attempted to subject their practice to the rigors of these new methods in order to proclaim scientific authenticity and secure patronage. During the sixteenth and early seventeenth centuries, reformist astrologers became scientific by appropriating the mathematics of Copernicus in order to sustain their legitimacy. This process worked particularly well within the English patronage system. However, while precise mathematics led to more accurate measurements in other arenas of scientific thought, precise predictions of planetary and stellar positions failed to yield more accurate predictions of human events. Giorgio de Santillana has defined science as "the search for impersonal invariants behind events."[294] Despite the best efforts of reformist astrologers,

[294] Santillana, *The Origins of Scientific Thought*, 12.

who girded judicial astrology with a new mathematical foundation, the events they sought to predict remained both highly personal and infinitely variable.

Astrology underwent major changes between the mid-sixteenth and mid-seventeenth centuries as reformers attempted to maintain its scientific status, and these modifications had both external and internal aspects. Externally, in England, social, cultural, and economic factors all transformed how scientists thought about astrology. The rise in overseas exploration, the increase in literacy among the popular classes, the founding of the Royal Society, and the shift in interest of astrology's principal financial supporters, the noble patrons, all deeply affected how astrologers practiced and how society valued them. Internally, the scientific process of attaining knowledge changed to incorporate new methods and new modes of inquiry. While mathematically precise calculations of the positions of the planets sufficed among scientific astrologers in the mid to late sixteenth century, this was no longer exclusively sufficient to be considered scientific by the mid seventeenth century. This process—both its external and internal variants—depended heavily on the primary audience of astrologers and who the arbiters of scientific value were. When it was patrons, practical, utilitarian concerns dominated. When it was the public at large, these concerns faded in importance next to the personal satisfaction that prognostication provided for astrological consumers. When it was scientists, by the mid-seventeenth century, more than merely mathematical precision was needed—astrology had to conform to the experimental method, to empirical evaluation, and to logical induction in order to be considered a science. Its inability to do so meant that scientists reclassified it beyond the boundaries of science.

The story of astrology's transformation is complicated. There is no monocausal explanation for why astrology changed when and how it did, and socio-cultural, economic, and methodological reasons all played a role. To speak of the demise of astrology, however, is to speak both ahistorically and with a clear retrospective bias. Because astrology ceased to be a science in the late seventeenth century, modern historians often write of its decline, failure, or death. But during this period of "decline" among the scientific community, astrology increased in popularity among the non-noble classes of England and transformed into the version that is most well-known today. Obviously, astrology is not dead—a simple perusal through the back pages of a newspaper or an Internet search reveal that it is very much alive and well.[295]

Much like the historian of science Wayne Shumaker, who, despite his admitted antipathy toward modern practitioners of occult arts, professed hope that "disbelief has not got in the way of comprehension," I have aspired to treat astrology on its own terms—which in early modern England means treating it as a science.[296] Shumaker urged historians to treat the history of the occult within the context of the "history of ideas, as research into mental patterns of a distant period from which we have inherited much that is precious," and astrology certainly fits this mold.[297] We must not forget that the same impulse that caused Copernicus to proclaim triumphantly that "in so many…ways do the planets bear witness to the earth's mobility" also gave astrologers the impetus to determine humanity's relationship with the cosmos.

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[295] As of April 2011, a search at www.google.com returns over forty nine million hits for "astrology" and over fifty million for "horoscope."
[296] Shumaker, *The Occult Sciences in the Renaissance*, xiv.
[297] Ibid.

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