THE COPERNICAN QUESTION

Prognostication, Skepticism, and Celestial Order

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Introduction

THE HISTORICAL PROBLEMATIC

Is the Earth motionless at the center of a finite, star-studded sphere, or is it a planet moving in an annual circuit around the center? Medieval scholastic natural philosophers debated all sorts of imaginative questions of this kind: whether there are, or could be, more worlds; if there were several worlds, whether the earth of one could be moved naturally to the center of another; whether the spots appearing on the Moon arise from differences in parts of the Moon or from something external; whether the Earth is fixed in the middle of the world and has the same center of gravity; and whether the Earth rotates around its axis.[1]

There were two motivations for entertaining such alternative possibilities. The first arose from natural philosophers answering theological worries about threats to God's unlimited, absolute power: for example, could God not make several worlds, if he so wished? But the second source of alternatives was already built into Aristotle's argumentational and rhetorical practices. Aristotle frequently reported the claims of his predecessors only to reject them in favor of his own positions. One such view was that of the Pythagoreans, who "affirm[ed] that the center is occupied by fire, and that the earth is one of the stars, and creates night and day as it travels in a circle about the center."[2] From the thirteenth to the seventeenth centuries, Aristotle's description of the Pythagorean view became a standard part of the argument that students learned—and then learned to reject—in support of the Earth's centrality and immobility. It was only sometime in the last years of the fifteenth and the first decade of the sixteenth century that a Polish church canon and sometime astronomical practitioner named Nicolaus Copernicus posed the Pythagorean idea to himself in a new way. He did so not in the thirteenth-century-philosophical style, as an alternative to be rejected, but rather as a mathematical assumption in the style of Claudius Ptolemy, reinterpreting the old Pythagorean idea as an astronomical explanation for two perplexing problems: first, the Sun's apparent motion as mirrored in the planets' motions, and second, the disputed ordering of Venus and Mercury. Yet not until 1543 did Copernicus finally publish a full-dress defense of this explanation and mobilize it as a vehicle for persuading others.

The Copernican Question opens with a paradox of historical context. Why ever did Copernicus concern himself about the order of the planets when the burgeoning late-fifteenth and early-sixteenth-century heavenly print literature, directed to learned elites and ordinary people alike, was overwhelmingly preoccupied with astrologically driven anticipations of the future, sometimes coupled with powerful apocalyptic fantasies that the world would soon come to an end? For those who read Copernicus's book, *De Revolutionibus Orbium Coelestium* (On the Revolutions of the Heavenly Spheres), what did getting the structure of the heavens right have to do with more accurately predicting the future? And with printing tech-

1. Theologian and astronomer-astrologer seeking concordance, [Petrus de] Alliaco 1490. Linda Hall Library of Science, Engineering & Technology.

nology making possible the production, circulation, and comparison of an increasing number of prophetic schemes, which prophecies or which combination of prophetic authorities—biblical, extrabiblical, astrological—were to be trusted?[3] Indeed, could heavenly knowledge support prophecy? During the Great Schism of 1378–1414, when the theologian Pierre d'Ailly worried that three men all claiming to be pope betokened the imminent arrival of the Antichrist, he turned for assistance to conjunctions of Saturn and Jupiter and slow, long-term motions of the sphere just beyond the fixed stars—seeking reassurance in a "concordance" of the Bible with astrology and ultimately concluding that the Antichrist's coming would not occur before 1789.[4]

Among those immersed in such categories and authorities was Copernicus's early contemporary, Christopher Columbus (1451–1506), who regarded his "Enterprise of the Indies" as but a step toward the fulfillment of his own guiding fantasy in the service of the Spanish crown: the liberation and reconquest of Jerusalem. Steeped in the astrological and biblical prophecies of Pierre d'Ailly and following Saint Augustine's figure of seven thousand years for the world's duration, Columbus believed that the world had entered its last 155 years. He regarded himself (invoking the meaning of his name as "Christ-bearer" [Christoferens]) as a major participant in the enactment of this drama: "God made me the messenger of the new heaven and the new earth of which he spoke in the Apocalypse of St. John after having spoken of it through the mouth of Isaiah; and he showed me the spot where to find it."[5]

Columbus was by no means the last discoverer to represent himself as a divine messenger heralding a new world, and he was far from the only one of Copernicus's contemporaries to be preoccupied with prophetic knowledge. Andreas Osiander, the influential Lutheran pastor who shepherded Copernicus's book through the press at Nuremberg, published in 1527 a prophecy "not in words, but in pictures alone," from materials appropriated from a much earlier prophecy—all meant to show the papacy's decline into tyranny, moral decay, and secular power as a powerful symptom of the end times.[6] And indeed, even as Galileo, Kepler, and others began to move the Copernican arrangement into the modernizing currents of the seventeenth century's first decade, they and other heavenly practitioners retained an intense preoccupation with the future.

Who, then, could be trusted to speak about the future in an age when the heavens were a major theater of cultural and political anxieties? And who decided which methods of prognostication were acceptable? Those were the major questions of the Copernican moment. But if so granted, then why did *De Revolutionibus* not make explicit a connection between planetary order and the success of astrological prognostication? In this book, I argue that Copernicus himself *did* see them as related even as early as his student days in Krakow and Bologna during the 1490s. Claudius Ptolemy's *Tetrabiblos*, the fundamental astrological text of antiquity, assigned to the planets certain essential capacities and differential powers to produce specific physical effects on Earth that were directly tied to the order of the planets. Because astrology depended on astronomy to deliver reliable positions for the planets, if astronomy's principles were called into doubt, then the relationship with the companion discipline was also imperiled. And indeed, the iconoclastic Renaissance philosopher Giovanni Pico della Mirandola (1463–94) undermined these very relations in his sharp, far-reaching assault on astrology, posthumously published in 1496. Uncertainty about astral powers and planetary order would become one of the problems—perhaps even the crucial one—to which Copernicus's reordering of the planets was a proposed, if unannounced, solution.

Historians—including myself—have not generally regarded the new Sun-centered ordering of Copernicus and his followers to involve a response to contemporary concerns about astral powers.[7] With the exception of the prescient suggestions of John North and Richard Lemay, scholars have granted to astrology no historiographically significant place in the Copernican literature.[8] This is to some extent understandable, as there is not a single word about celestial influences in any of Copernicus's extant writings. Conceptual revolution, the idiom in which the long-term Copernican narrative was most often cast in the twentieth century, effectively hid these kinds of questions from scrutiny because it foregrounded the physical problems raised by Copernicus's achievement as the first step on the road to the great breakthroughs of seventeenth-century natural philosophy. The narrative of the "Copernican Revolution" is organized around discovery, diffusion, reception, and assimilation. Theoretical illumination or breakthrough provides the narrative center; the subsequent epistemic history charts theoretical amplification, empirical verification, and sometimes obdurate resistance to truth, while exiling prediction to the thematic backcountry.

Thomas S. Kuhn's still-influential, philosophically informed historical study *The Copernican Revolution* is one variant of this kind of historical writing; elements of it may be found as early as William Whewell's *History of the Inductive Sciences* (1837).[9] When Kuhn called Copernicus's achievement "revolution-making" rather than "revolutionary," he meant to suggest that Copernicus's own contribution was incomplete; other things had to happen in order to consummate the change. Copernicus's contribution was to work out a series of detailed planetary models that fit together as a genuinely interconnected system rather than as a group of discrete calculational devices. He pursued this theory in the face of observed effects, like falling bodies, that he could not convincingly explain. Still, the new theoretical framework that he opened functioned as a heuristic that allowed and encouraged others to think differently and, over time, to accommodate more and more evidence coherently within the new ordering of the universe. Thus Kuhn's account is not "realist" in any straightforward sense; it was not so much the new theory's correspondence to reality, its "truth-to-nature," but rather its "fruitfulness," its heuristic power, that was noteworthy. Copernicus's original insight, on this account, both culminated an earlier tradition and initiated a new one, a crucial imbrication without which Kepler, Galileo, and Newton might not have imagined their worlds. A fundamental innovation in the relatively narrow technical specialty of astronomy "transformed neighboring sciences and, more slowly, the worlds of the philosopher and the educated layman." It was in this sense, rather than in the paradigm-changing rupture of his later work, that Kuhn regarded the entire development as a revolution that Copernicus initiated and of which he was a necessary and central part.[10]

Talk of "deep" revolution or long-term upheaval at the level of both scientific concepts and standards no longer comes as easily as it did at the time of Kuhn's original writing in those historiographically optimistic, if not quite innocent, years following the end of World War II.[11] Nostalgia for so-called big-picture history still exists, but for many it is strongly resisted by a sense that only something like an anthropological immersion in local sites of knowledge making—seeing things "from the native's point of view"—can yield real insight about the actual practices of science.[12] Yet, as revealing as such concentrated localist probings may be, the anthropological tool kit does not provide the methods needed to study change over long periods.[13] Quite the contrary: this approach leaves open the task of explaining how, across time, specific readings, meanings and evaluative judgments made in one cultural setting circulated, metamorphosed, persuaded, or dropped away in others. The present study takes seriously the elements of both sorts of projects—meanings formed at local sites as well as the long-term movement of standards, reasons, and theoretical commitments—seeking a treacherous middle course between the Scylla of internalist conceptualism and the Charybdis of the localist turn.

By way of introduction, consider the specific questions and difficulties that Copernicus's work raised for sixteenth-century readers. First, if the main problem faced by sixteenth-century heavenly practitioners was how to shut down, or at least limit, doubts about predicting the future—whether the occurrence of celestial events, human happenings in the near term, or the end of the world—after 1543, they had to consider whether reordering the planets would help in those efforts. Yet Copernicus's reordering was far from the only strategy that might be used to make astrology's predictions persuasive; indeed, as rapidly became clear, some saw his planetary models rather than his planetary arrangement as having a bearing on the casting of new tables of motions. In any case, the sixteenth century witnessed many different approaches to these questions, all of them beset by difficulties. Moreover, the heliostatic ordering itself came at the price of introducing new kinds of objections, many of them quite serious.

One immediate and enduring problem lay in the preeminent astronomical text of antiquity, Claudius Ptolemy's *Almagest*. Ptolemy's work enjoyed a revival in the fifteenth century largely through the efforts of Georg Peurbach (1423–61) and his brilliant pupil Johannes Regiomontanus (1436–76), who both completed Peurbach's translation and added to it some of his own ideas. In Regiomontanus's *Epitome of the Almagest* (1496), late-fifteenth-century readers could learn that Ptolemy had anticipated the possibility of the Earth's daily motion and produced arguments to show its absurdity.[14] The other major problem for the rehabilitated Pythagorean view, conflict with the Bible's authority about what moves and what does not, was obviously not a concern of the pagan Alexandrian Ptolemy—nor even yet one which elicited comment from Regiomontanus—but it clearly was by the time that Copernicus's book appeared. Catholic theologians and Protestant reformers alike regarded Scripture as a criterion of the truth of heavenly knowledge. For astrologically inclined practitioners, however, the main question was whether you could extract prognosticatory benefits from Copernicus's proposal without taking on board the parts of it that undermined Aristotelian physical intuitions and ran up against those passages of the Bible that could be read literally as resisting the Earth's motion. In other words, could the theory's utility as an instrument of prediction be separated from its physical truth and scriptural compatibility?

The inclusion of scripture among the criteria considered essential to judge the adequacy of claims about the heavens became ever more urgent during the Protestant Reformation and the overlapping period of Catholic spiritual renewal and response in the sixteenth century. It was widely held that divine messages could be read both in the words of the Bible and in events of the natural and civil worlds. But what was the relation between the Bible and these events? Should the words and sentences of the Bible be taken always to mean literally what they said and, for that reason, to describe actual events and physical truths? Was the subject matter of the biblical text always conveyed by the literal or historical meaning of its words? And who had the ultimate authority to decide on the mode of interpretation appropriate to a given passage? Finally, when the subject matters of two different kinds of texts were seen to coincide—for example, astronomical-astrological with biblical, or astronomical with natural-philosophical—who had the authority to decide which standards of meaning, and truth should govern their assessment? Questions of this sort were inextricably interwoven into issues faced by Copernicus's sixteenth- and early-seventeenth-century followers.

Beyond scriptural and physical criteria, there were other, more strictly logical standards for judging claims about heavenly motions. But, again, who was taken to have the authority to decide which standard should prevail? For celestial prognosticators, tables of mean motions and observations were the principal standard. Yet from the observational evidence alone, long available since antiquity—daily risings and settings of heavenly bodies, retrograde motions, changes in speed, the occurrence of eclipses, and so forth—Copernicus could not deduce a theory uniquely founded on the Earth's motion.[15] Worse still, if Copernicus aspired to make even stronger claims about the nature of reality, then he would have to satisfy a logical ideal widely held among philosophers. Aristotle's standard of scientific demonstration—never itself a logic of discovery—raised the bar impossibly high: it demanded a syllogism called *apodictic,* in which from a true, necessary, and incontrovertible major premise, a true conclusion was inferred. Yet the logic of Copernicus's central claim did not fit that stringent argument-form because, like Ptolemy in his *Almagest,* Copernicus used the less robust conditional syllogism as his preferred pattern of reasoning—starting with the Earth's motion as an assumed, rather than incontrovertibly true, premise. In that sense, it was a supposition or hypothesis that might or might not be true, yet from which true consequences could be deduced.

To add to such logical considerations, Copernicus had opened a question that had been glimpsed in antiquity but which previously had not been seen to possess far-reaching consequences: how to choose between different models of heavenly motion supported indifferently by the same observational evidence. A simple version of this problem had appeared around the first century B.C., when the Alexandrian Greeks Apollonius and Hipparchus recognized the phenomenon of geometrical equivalence for the case of two different models of the Sun's motion: the simple eccentric and epicycle-cum-deferent.[16] Ptolemy's reference to this problem when discussing his own model for the Sun was a major source for sixteenth-century writers.[17] Those who read Ptolemy in Regiomontanus's *Epitome,* however, were shown an equivalence that went unrecognized in the *Almagest:* transformation of epicyclic into eccentric models for the inferior planets, Venus and Mercury.[18] Not until 1543 did geometrical equivalence show up as a question of much wider significance, the choice between arranging the entire heavens around a Ptolemaic-Aristotelian central Earth or a Copernican central Sun. As Copernicus himself put the matter: "It makes no difference that what they [the ancients] explain by a resting Earth and a universe whirling round, we take up in the opposite way so that together with them we might rush to the same goal. For in such matters, those things that are thus mutually related agree, in turn, one with the other."[19]

Visualizing these geometrical transformations was by no means straightforward. Early readers who focused only on the now-famous diagram of concentric circles in book 1, chapter 10, would have had trouble appreciating the passage's real significance. Work would be needed to bring out the equivalences. The same applies to the Earth's motion(s) as the source of visual illusions:

> Why should we not admit that the appearance of daily revolution is in the heavens but the truth [*veritatem*] in the [motion of the] earth? This situation closely resembles what Virgil's Aeneas says: "Forth from the harbor we sail, and the land and the cities slip backward." For when a ship is floating calmly along, the sailors see the image [*imago*] of its motion in everything outside, while on the other hand they suppose that they are stationary, together with everything on board. In the same way, the motion of the earth can unquestionably produce the impression that the entire universe goes around.[20]

Throughout his main argument, Copernicus played on such deceptions of the visual *imago.* But the boat analogy addresses only one motion. The Earth was not just "floating calmly along." It was describing a more complex motion, something like a carnival horse on an imaginary merry-go-round—able to rotate daily with respect to its own axial pole while simultaneously revolving, over a period of a year, in the opposite direction with respect to the platform's central axis. However, such planetary merry-go-rounds, or orreries, would not enjoy their heyday as visual assists until the eighteenth century (see figure 34).[21] At best, Copernicus could argue that if the Earth has an additional, annual motion, then that motion would be apparent in viewing the other planets, showing up as "a sort of parallax produced by the earth's motion."[22] Each of the planets mirrors the Earth's unfelt motion as a component of its own total motion.

In comparable language, known to Copernicus, Peurbach had already called attention to this same peculiar phenomenon with reference to the Sun: "It is evident that each of the six planets shares something with the sun in their motions and that the motion of the sun is like some common mirror and rule of measurement to their motions."[23] Had Copernicus drawn explicit attention to this passage in Peurbach's book, widely taught in the universities, it might have helped to highlight this problem, if not to persuade otherwise skeptical readers that he offered a viable solution to it. But Copernicus makes no references to Peurbach and, for that matter, few to other contemporaries. Good humanist that he was, Copernicus represented himself as though in an exclusive dialogue with the ancients. Meanwhile, other observational consequences, such as the variation of the Moon's apparent diameter, in which Copernicus claimed "greater certainty" than Ptolemy, in no way depended on the new ordering of the planets.[24] Modern reconstructions of the mutual advantages and disadvantages of the Copernican and Ptolemaic arrangements have made these considerations much easier to grasp; yet, as a consequence, they have unwittingly made the situation faced by contemporaries seem more obvious than it really was.

Hindsight may also intrude in another way. The heliostatic theory, taken as a timeless entity all of whose entailments are known, predicts certain effects that were not immediately observed. The historical question is, when did those effects become real questions for the agents? And further, when and how were those effects seen to be implications of the Sun-centered theory rather than of its alternative? For example, if the Earth moves, you ought to be able to detect a slight parallactic effect in a distant star; over a period of six months or a year, the star should appear to shift its position. Also, Mars at opposition should have a diurnal parallax greater than the Sun and hence should be closer than the Sun to the Earth. Or yet again, if Venus is revolving around the Sun, then it ought to display a complete set of phases, like the Earth's moon. And finally, if the Earth is set in motion, the resulting distances create serious problems regarding the plenum of nesting eccentric spheres that many believed transported the planets themselves. In 1543, Copernicus himself recognized that the Earth's motion entailed the appearance of an annual parallactic effect in the fixed stars, and he acknowledged that the stars exhibited no such appearance; however, he did not allude to the possibility of Venusian phases; and, as he was hardly a systematic natural philosopher, he did not comment unambiguously on the ontology of the heavenly spheres.[25] Copernicus explained the absence of parallax as a consequence of the universe's large, hitherto-underappreciated size. However, his first disciple, Georg Joachim Rheticus (1514–74), stated quite bluntly that "Mars unquestionably admits a parallax sometimes greater than the sun's" and then proceeded to infer that "therefore, it seems impossible that the earth should occupy the center of the universe."[26] The question of measuring stellar—or planetary—parallax does not seem to have been grasped as approachable by anyone before Tycho Brahe in the 1580s and, yet more optimistically, by Galileo after 1610; and there was no stable consensus that the problem had been resolved until Wilhelm Gottfried Bessel produced measurements of stellar parallax in 1838.[27]

Another sort of entailment concerned physical effects inferred from observations unmediated by any sort of new technologies of magnification. If, contrary to ordinary sense experience, the Earth can be imagined to rotate in twenty-four hours from west to east [A], then, if you have Aristotelian intuitions, you will expect all kinds of calamitous terrestrial effects [B]. Ptolemy himself had already articulated just such objections:

> [B:] All objects not actually standing on the earth would appear to have the same motion, opposite to that of the earth: neither clouds nor other flying or thrown objects would ever be seen moving towards the east, since the earth's motion towards the east

> would always outrun and overtake them, so that all other objects would seem to move in the direction of the west and the rear. . . . Yet [not-B:] we quite plainly see that they do undergo all these kinds of motion, in such a way that they are not even slowed down or speeded up at all by any motion of the earth.[28]

The argument pattern in this example, as in the argument from stellar parallax, was that known to logicians as *modus tollens:* if A, then B; but not-B, therefore, not-A. The real workhorse in logically valid reasoning of this sort is denial of the consequent, not-B—the premise standing for unobserved or unmeasured effects—just as it had been in the reasoning patterns of various sorts of Greek scientific and medical writings.[29]

Against Ptolemy and Aristotle, Copernicus sketched an alternative theory of gravity that retained the intelligibility of Aristotle's "natural," "simple," and "place" as the right categories in which to describe and explain motion. But then Copernicus reshuffled Aristotle's natural motions, assigning uniform circular motion to the Earth, the planets, and the elements and demoting all rectilinear motions to the status of temporary, nonuniform deviations from circularity.[30] In this new account, all the planets shared "a certain natural desire, which the divine providence of the Creator of all things has implanted in the parts, to gather as a unity and a whole by combining in the form of a globe."[31] Hence, if [A] the Earth rotates daily and/or revolves around the Sun annually, then, as in Ptolemy's implication [not-B] above, objects detached from the Earth would not appear to speed up or slow down.

That Copernicus even troubled to devise an alternative to the Ptolemaic-Aristotelian theory of gravity shows that he was working to recast his role as a traditional astronomer-astrologer principally concerned with prognostication—that he was actively looking for alternative arguments to block objections from traditional natural philosophy. This move, in turn, raises the specific historical question of how Copernicus convinced himself to pursue his own seemingly absurd hypothesis, at least as a conditional argument, sometime between 1497 and 1510. Certainly, a major consideration must have been his recognition that the assumption of a Sun-fixed ordering allows many observations to be intelligibly connected in a way that has no comparable explanation on the Ptolemaic account.[32] Perhaps Copernicus intuited that such "explanatory loveliness" betokened the potential for inferring the best possible explanation of the planetary phenomena and their arrangement.[33] In 1543, *De Revolutionibus* foregrounded its most lovely entailment—the universe's well-proportioned orderliness or *symmetria:* from the assumption of the Earth's motions, "not only do [planetary] phenomena follow therefrom but also the order and size of all the planets and spheres, and heaven itself is so linked together that in no portion of it can anything be shifted without disrupting the remaining parts and the universe as a whole."[34]

This was surely a new claim. Ptolemy (and Regiomontanus) had failed to mention these consequences for planetary order that Copernicus detected on setting the Earth in annual motion, although they had noticed and rejected the physical consequences of the Earth's daily rotation. Yet whatever explanatory gain Copernicus had found, his reasoning, like Ptolemy's, also follows a conditional form. To many contemporaries, it was quickly obvious that the argument violated *modus tollens* because, strictly speaking, Copernicus would have been making an invalid inference called "affirming the consequent": If A, then B; B is affirmed, therefore A follows. If Copernicus was in possession of other arguments, he chose not to make such crucial evidence part of his public presentation in *De Revolutionibus,* nor did he claim that his theory yielded tables of motions superior to those of Ptolemy. Indeed, why would he have withheld his best evidence—after some four decades of considered reflection—if he really possessed it? Further, if the predictions yielded by the new arrangement were no better than the alternative, then how could it possibly be said to improve astronomical *or* astrological forecasting? These questions of evaluative judgment, not fully or clearly unpacked in the compact phrasing and limited visualizations of *De Revolutionibus,* greatly affected the considerations of later practitioners.

Finally, there are questions of how celestial practitioners (and nonpractitioners) responded in the face of negative or even potentially refuting instances as well as inferences that were drawn from confirmations. Astrology's predictions frequently failed or, at least, appeared to fail. Who could tell whether this was the fault of inaccuracies in the planetary tables, the principles on which those tables were based, or the astrologers' interpretations of the chart based on the planetary positions? And to reverse the question, if Copernicus's hypothesis was taken to be true, would that guarantee the accuracy of the astronomical (or astrological) predictions based upon it? Similarly, what inferences might be drawn about the truth of Copernicus's hypothesis from belief in the success of the ephemerides derived from the Copernican planetary tables? For, in following Aristotle's apodictic standard of demonstration, how could any of Copernicus's advocates be sure that they had met the demanding standard that ruled out all possible alternative arrangements?

The scientist, philosopher, and historian Pierre Duhem (1861–1916), who studied and commented on many of the original texts involved in the Copernican episode, was the first to call attention to this last question as a problem of broader epistemological interest. Among philosophers of science, it has since come to be known as the problem of *underdetermination*.[35] In an 1894 essay, Duhem maintained that a physical theory is not an isolated hypothesis analogous to the wheels and cogs of a watch that can be disassembled into its individual parts. Rather, a physical theory is like an organism that must be taken as a "whole theoretical group": "Presented with a sick person, the doctor cannot perform a dissection to establish a diagnosis. The doctor must decide the seat of the illness only by inspecting the effects produced on the whole body. The physicist charged with reforming a defective theory resembles the doctor, not the watchmaker."[36]

Dramatic and sobering consequences follow from this vestige of late-nineteenth-century holism. First, if a physical theory is holistic rather than atomistic—an interconnected network rather than a set of independently standing empirical propositions—it is uncertain at best which parts of the theory are refuted when a prediction (or an experiment) fails. In the 1950s, the philosopher W. V. O. Quine further radicalized Duhem's claim by arguing that when Nature pushes back at a theory, it is always possible to make pragmatic adjustments or additions to the beliefs that make up the theory so that, at least logically, one is never forced to give up the whole web of beliefs. For my purposes it is unnecessary to consider the different possible interpretations of Quine's views.[37] But it is worth noting an especially radical version of Quine's thesis that maintains that "*any* seemingly disconfirming observational evidence can *always* be accommodated to *any* theory."[38] Physical theories on this account thus have unusual staying power. Apparently endless adjustments can block the refutations of *modus tollens*. A further significant consequence is that both Duhem and Quine denied the possibility of crucial experiments in physics. In geometry, you can follow the method of exhaustion, reducing all contrary propositions to absurdity; but in physics you cannot because, as Duhem argued, you "are never certain that [you] have exhausted all the imaginable hypotheses concerning a group of phenomena."[39] How then could a theory's full web of background assumptions ever be shown to be refuted?

Sixteenth-century celestial practitioners, of course, were not aware of underdetermination as a general epistemological problem. At ground level, Copernicus's followers and his adversaries were simply cognizant of the problem of blocking the uncertainties and refutations produced by rival alternative accounts. All sides, indeed, shared considerable confidence that demonstrations, sometimes quite strong ones, could be delivered. And it is these historically situated efforts that will especially interest me in this book. Only from the perspective of long historical distance can the Copernican question be viewed, epistemologically, as the first full-scale "Duhemian situation" in the history of science—and even then, not in the sense that Duhem or Kuhn imagined.[40] Duhem, for his part, read the history of astronomical theory from the Greeks to the Renaissance as vindicating a powerful scientific antirealism, the view that the propositions of science predict but do not describe features of the world.[41] In his classic essay *To Save the Phenomena* (1908), Duhem famously read Copernicus, Kepler, and Galileo as misguided in pursuing a realist theory, one that they believed corresponded to the world. The difficulty for Duhem was that these thinkers had prematurely abandoned the well-founded tradition of treating astronomy's models as no more than convenient predictive instruments that "saved the phenomena" but with no claim to truth. Had they remained committed to the view that astronomical hypotheses are fictions, Duhem counseled, then the problem of ranking geometrically equivalent hypotheses would have been irrelevant. According to Duhem's provocative—and oversimplified—interpretation, the Church was scientifically warranted in maintaining a skeptical view of Galileo's Copernican claims. The Church was thus made to stand squarely in line with Duhem's reading of astronomical tradition from the time of the Greeks. Even before Maffeo Barberini became Pope Urban VIII in 1623, he warned Galileo that God, being all-powerful and omniscient, already knows all possible orderings of the universe; and yet, as the medievals had often argued, he chose to use his unfathomable power to build only a finite universe, a view long taught by the Church as a matter of tradition.[42] Humans, opined the pope, were not to fall prey to their own pride in believing that they could imagine all other possible worlds. "The man who was to become Urban VIII," wrote Duhem,

> had clearly reminded Galileo of this truth: No matter how numerous and precise are experimental confirmations, they can never render a hypothesis certain, for this would require, in addition, demonstration of the proposition that these same experimental facts would forcibly contradict all other imaginable hypotheses.
>
> Did these logical and prudent admonitions of [Cardinal Robert] Bellarmine and Urban VIII convince Galileo, sway him from his exaggerated confidence in the scope of experimental method, and in the value of astronomical hypotheses? We may well doubt it.[43]

Powerful words, perhaps not unexpected from a believer who wished to harmonize the truths of nature—or at least its methods of investigation—with those approved by the Church. But, although Duhem was a brilliant investigator, the first to establish the existence of a flourishing scientific culture in the medieval period, his own antirealist commitments led him to indulge in some historical attributions that are questionable at best, wrong at worst. For example, Duhem dubiously attributed to Galileo an "impenitent realism" that made him appear to hold that Copernicus's theory had been incontrovertibly demonstrated. It was this position that Duhem's Urban then corrected with his theologically-grounded skepticism. Thus, ultimately the blame for Galileo's condemnation was to be assigned to the Copernicans' excessive zeal for an "illogical realism."[44] Likewise, as Geoffrey Lloyd has shown, Duhem's reading of the core ancient writers Geminus, Proclus, Ptolemy, Simplicius, Theon, Hipparchus, and Aristotle do not support the Duhemian interpretation of a robust astronomical instrumentalism.[45] Moreover, Peter Barker and Bernard Goldstein have unearthed passages in some sixteenth-century astronomical writings that further deflate confidence in a global application of the distinction between realism and instrumentalism.[46] And Maurice Clavelin has pointed out that Duhem's unmitigated continuist perspective, which regarded Galileo's theories of motion as nothing more than developments of fourteenth-century natural philosophy, had the effect of marginalizing the Copernican framework as an alternative approach for Galileo's science of motion—in effect, regarding it as "a detail without conceptual implications."[47]

The danger of imposing inappropriate analytic categories points again to the need for a more rigorous historicism, ruthlessly attentive to the pastness of the agents' own categories but also informed and balanced by a judicious cultivation of modern epistemic resources. Such an investigation, beginning with a careful excavation of the resources for classifying knowledge, finds Copernicus and his successors engaged in trying to answer a series of questions in which the premises of astronomy and astrology were somehow linked. In this sense, one might say that both Duhem and the early Kuhn, whose *Copernican Revolution* bears signs of Duhem's influence, were insufficiently holistic in their historical treatment of astronomy and astrology. Once we see the two as part of a shared complex, we can ask new questions. For example, how could an astronomy believed to be well grounded secure the foundations of astrology against criticism and refutation? What astronomical choices were open to practitioners in the face of astrology's often failed predictions? How did Copernicus and his followers seek to eliminate the traditional, alternative world ordering while advancing proofs for their own? What difference did it make that there were two alternative planetary arrangements when a comet and a nova appeared unexpectedly in the 1570s? And how were these choices made within the space of the logical, rhetorical, literary, and disciplinary possibilities available to the people of that long-ago time?

SUMMARY AND PLAN OF THIS WORK

This book is divided into six parts. Chronologically, it ranges from Copernicus's intellectual for-

4

Between Wittenberg and Rome

THE NEW SYSTEM, ASTROLOGY, AND THE END OF THE WORLD

Copernicus first formulated his new arrangement of the heavens amid the intellectual skepticism and political insecurity of the late fifteenth- and early-sixteenth-century prognosticatory culture of the northern Italian university towns. When his mature hypotheses of celestial order finally appeared between 1540 and 1543, however, it was at a time of historic upheaval no less conflicted about the legitimacy of knowledge of astral forces and their effects. Both the Roman church and the German Protestant reform movement were obsessed with world-historical biblical prophecies; but for the Lutherans there was, as Robin Barnes has argued, a uniquely urgent sense of imminent crisis and belief in an apocalyptic "End of Time."[1] The world was going to end soon. But when? And what natural "signs" of the divine plan were reliable indicators of this end? Neither the questions nor the apocalyptic resources were entirely new: they were all appropriated from well-established medieval sources.[2] But now the apocalyptic sensibility was heightened by Martin Luther's break with the Church. For Luther, Rome was the seat of the Antichrist, and the "last days" were rapidly approaching. In the dedication to his translation of the Book of Daniel (1530), he told his protector, John Frederick of Saxony, that "the world is running faster and faster, hastening towards its end, so that I often have the strong impression that the Last Day may break before we have turned the Holy Scriptures into German."[3]

On the eve of the Council of Trent (1545–63), Copernicus's hypotheses quickly became the occasion for discussion and engagement among students of the heavens at Lutheran Wittenberg. The question was no longer merely whether prognostication of natural events could be accommodated to a Bible-governed narrative, but rather what relevance the Bible had for conflicting hypotheses of celestial order in theoretical astronomy. What implications did the new hypothesis of heavenly order hold for various sorts of theoretical and practical divination? And was this order really a manifestation of God's plan for the world?

The agents most immediately involved in transforming Copernicus's manuscript into printed texts were all preoccupied, in one way or another, with prognosticatory and apocalyptic considerations. They were also Lutherans who were located either in Wittenberg or its main outpost in southern Germany, the powerful city of Nuremberg: Georg Joachim Rheticus (1514–74), a protégé of Philipp Melanchthon (1497–1560) at Wittenberg; Johannes Schöner (1477–1547), the dedicatee of Rheticus's *Narratio Prima* (1540); Andreas Osiander (1497–1552), the influential Nuremberg preacher; Achilles Pirmin Gasser (1505–77), a pupil of Schöner and Melanchthon, later town physician of Feldkirch, and the author of a prefatory letter to the second edition of the *Narratio;* and Johannes Petreius (1497–1550), the Nuremberg publisher who had also studied at Wittenberg.

By 1543 there were three representations of Copernicus's new celestial scheme. The *Commentariolus* was known in a limited way in Catholic circles in Varmia and in Rome.[4] The two published accounts—the *Narratio Prima* (First Narration) and *De Revolutionibus*—were carefully crafted to appeal to different audiences. The first was implicitly directed to a Lutheran audience; the second was formally dedicated to the Pope.[5] Rheticus, undoubtedly with Copernicus's approval, addressed his *Narratio Prima* to Schöner, a widely reputed Nuremberg astrologer, prognosticator, and geographer who taught mathematical subjects at the city's *Gymnasium* from 1526 onward. Schöner was at first a Catholic and (unlike Copernicus) a priest and a chaplain (to the Bishop of Bamberg). He soon, however, moved easily into the politically moderate intellectual orbit of the Wittenberg reformer Philipp Melanchthon and developed a friendship with Andreas Hosemann, or Osiander.[6] He sided with the Reformation in Nuremberg, married, and had a son.[7]

Copernicus, meanwhile, dedicated *De Revolutionibus* to Paul III, a pope renowned for his wide learning and patronage of astrologers (such as Luca Gaurico), but also, like Melanchthon, well schooled in Greek. Among other accomplishments, he had called into session a reforming council at Trent, and under his reign both the Roman Inquisition and the new order of the Society of Jesus were founded. Just as Rheticus's name was excluded from any mention in *De Revolutionibus*, so the pope's name was not used in the *Narratio*.[8] Evidently, Copernicus's and Rheticus's dedicatory decisions were part of a dual strategy to shape a favorable reception for the new world hypotheses in a Europe that was just beginning to show evidence of serious splits along confessional lines.

MELANCHTHON, PICO, AND NATURALISTIC DIVINATION

University courses built around Aristotle's physical teachings and disputed by scholastic philosophers and theologians constituted the main arena for debating questions about the nature of the heavens in the Middle Ages; and, as Edward Grant has shown, such discussions, posed in the question-answer format, persisted well into the seventeenth century. But the school philosophers, perhaps affected by the Church's serious injunctions concerning the stars' threat to human free will, gave little or no space to astrological matters.[9] Resistance to the inclusion of astrology in natural philosophy began to change significantly during the Reformation. The crucial figure in this development was Melanchthon, rector of the university where Luther taught and known famously as the *Praeceptor Germaniae* (Teacher of Germany).

The Lutheran reformers were by no means united in their assessment of the value of natural knowledge. Martin Luther himself undoubtedly encouraged his followers in the work of prophetic interpretation—he even wrote a preface to Johannes Lichtenberger's prophecies—but he was distinctly ambivalent about naturalistic prophecy compared with Melanchthon, his close associate.[10] Throughout his life, Melanchthon advocated a strongly naturalistic theology. Commentators have variously characterized it—Stefano Caroti, for example, has called it a "theophanic view of reality" and Sachiko Kusukawa a "providential natural philosophy."[11] In Melanchthon's view, the Creator disclosed his providential plan through natural signs and great historical events; the Word was revealed as much through nature as through scripture and history. The point was to make systematic theology hegemonic in all naturalistic investigation. Harmony, design, order, and intent were visible in the created works. Also, certain persons, according to Melanchthon, had special gifts of prophecy that permitted "secret insight or otherwise hidden sense." Sometimes prophetic insight came in dreams that were subsequently fulfilled. Even here, it was stellar influence that caused "the inborn and natural prophetic power hidden in men to be awakened and excited to such an extent as to announce future things."[12]

Divinatory practice was thus not only a legitimate expression of the natural desire to know the Creator's works and to achieve divine grace, but it was also ethically desirable: it made one a better Christian.[13] Melanchthon gave the widest latitude and authority to all kinds of well-established naturalistic divination, ranging from medical astrology to dream interpretation and the interpretation of monstrous births, portentous comets, and other *mirabilia naturae*.[14] Also, having studied at Tübingen with Johannes Stöffler, Melanchthon had been deeply impressed by the claims of the prognosticators. Even the failure of the 1524 flood forecast did not, so to speak, dampen his enthusiasm.[15] On the other hand, Luther regarded Melanchthon's views with skepticism:

> It pains me that Philipp Melanchthon is so strongly devoted to astrology, because most of the time he is

31. Lucas Cranach, *Philipp Melanchthon*, 1532. Courtesy National Gallery of Victoria, Melbourne.

> deceived. For he is easily impressed by heavenly signs and fooled by his conceptions. He has often failed, but he cannot be convinced otherwise. Once when I arrived from Torgau, quite exhausted, he said that my death was imminent. I have never wanted to believe that it was so serious. I do not fear the heavenly signs because man is greater than all the stars and cannot be subjected to them. Were our bodies to be subjected to them, I [still] would not fear the heavenly signs. That I shall leave to the clever wise men.

And, in his *Table Talks,* Luther exclaimed: "Nobody will ever persuade me, for I can easily overturn their flimsy evidence. They take note of everything that supports their case; whatever does not, they pass over in silence. If a man throws a dice for long enough, he will throw Venus, but that happens by chance. That art of theirs is so much manure [*dreck*]."[16] His final word on astrology was: "Whoever fears the influences of the stars should know that prayer is stronger than stargazing."[17]

Luther's views would prove to be typical of theologians in the sixteenth century. Melanchthon, on the other hand, was keen to wrap a protective belt around astrology: he regarded some divinatory practice as illegitimate or, more to the point, superstitious and diabolical. The critical issue was the maintenance of the authority of scripture and divine providence. Wherever God and his Word were endangered by errors and excesses, there lay the work of the devil.[18] Interpreting biblical miracles astrologically in the manner advocated by Pierre d'Ailly, for example, was considered to be dangerous.[19] Also, Melanchthon rejected forecasting for its own sake as "vain curiosity" and "superstitious divinations."[20] He regarded prognosticatory questions like "Who will be victorious, France or Burgundy?" as undesirable because they were devoid of providential import.[21]

In 1553, Melanchthon's son-in-law Caspar Peucer (pronounced *Beucker*) produced a massive work of classification. Peucer's aim was to demarcate Christian from diabolical divination, and his work covered not only astrology but also many other kinds of divination, such as from the parts of the body (chiromancy) and from animal entrails.[22] Most natural divination is good, so he maintained, because it is based on natural or physical causes, but, in practice, things are not always easy, because matter is unstable: mixtures of primary qualities keep changing, and thus so do predicted outcomes. The devil is a trickster. Demons delude people's imaginations, causing them to believe that they can do things that they cannot do. For example, demons can simulate legitimate activities such as the making of predictions or the production of cures. The Catholic use of relics and invocation of saints were good examples of the devil's activities. But, toward all forms of astrology—with the exception of astrological images created by human artifice—Peucer was quite favorably disposed. Although astrology could be abused, there was a true and legitimate astrology deriving its justification from the "force of light" created at the beginning of the world—as described in Genesis—and, of course, from that part of the science of the stars that describes the celestial motions and measures distances and intervals between bodies and the sizes of bodies and orbs.[23]

For Melanchthon, anyone opposed to the sciences of the natural order was seen to have endorsed an Epicurean theology, a world of matter devoid of meaning and divine purpose. And to Melanchthon, the principal opponent of the divinatory sciences was none other than Giovanni Pico della Mirandola. Pico's views were not merely wrong; they could seriously mislead the young. Melanchthon regarded Schöner as an ally in this endeavor to protect students against Pico's pernicious claims. Schöner said that he had seen a handwritten marginal note in a copy of the 1504 Strasbourg edition of Pico's *Disputationes* owned by the bishop of Bamberg. This note accused Pico of plagiarizing all of his ideas from unidentified authors.[24] Rheticus knew about this comment directly through Schöner, and his knowledge of it then passed, probably by word of mouth, to Melanchthon and Copernicus.[25] In a world where large private libraries were still rare, knowledge that people believed to be trustworthy could be discovered not only in the printed word but in comments written in the margins.

Melanchthon's reputation as a pedagogue was no accident. His books were extraordinarily influential models of pedagogy. They offered clear definitions of terms and effectively chosen examples and drew on a comprehensive range of ancient, medieval, and modern authorities. He organized his books in scholastic form as questions, with extensive answers ordered in the form of arguments. Among other topics, he wrote textbooks of dialectic, rhetoric, and physics as well as extensive commentaries on the Psalms, the Book of Daniel, and Genesis. Many of his writings were also cast as prefaces to student texts or to the writings of authors whose views he wished to promote. When he announced his intention to write a full defense of astrology against Pico, he selected as his venue a preface to Johannes Schöner's *Tabulae Astronomicae Resolutae* (1536).

> From the stars' positions many things may be revealed about bodily health, about talents and temperaments, about many misfortunes in life, stormy weather, and changes in republics. But most of all, contemplation and attention to such matters is conducive to prudent behavior. The Christian religion neither objects to this opinion, nor do sacred writings damn such predictions, for they occupy the same part of Physics as do the predictions of the medical doctors; and, in fact, they presume natural causes. Some heavenly influence is imparted by the Sun, some by the Moon, as though some is like the force of pepper, the other like the force of a purgative; therefore, it is both pious to understand God's works and to observe the forces imparted to them. However, this entire argument is longer than can be treated here, and there are many books, written most eruditely, which answer the dishonest accusations of Pico and others.[26]

The continuing need to defend astrology against Pico's arguments in the 1530s and '40s shows that the force of Piconian skepticism had by no means dissipated.[27]

Melanchthon's and Camerarius's "purified" humanist translations of the *Tetrabiblos*, alluded to in chapter 1, became the principal texts for avoiding excessive reliance on Arabic conjunctionist astrology and for reaffirming Christian authority. The *Tetrabiblos* constituted the center of the natural philosophical curriculum at Wittenberg. Systematic justification for astrological knowledge was a prelude to its inclusion in teaching about the natural world. Melanchthon developed his views in several places, of which two are especially important: the preface to Schöner's *De Iudiciis Nativitatum* (1545) and his textbook of natural philosophy, the *Initia Doctrinae Physicae* (1549). In both places, Melanchthon kept the traditional two-cell distinction between the principal parts of the science of the stars, "of which the one shows the most certain laws of motion, the other, *mantike* or divination, shows the effects or meanings of the stars."[28] Now, it is clear that Melanchthon considered Pico's main threat to astrology to be the attack on the divinatory part, theoretical and practical astrology, rather than the attack on theoretical astronomy that had worried Copernicus. The *Praeceptor Germaniae* believed that Pico's arguments—which, following Rheticus, he believed to have been plagiarized—had been refuted by "learned men, [Lucio] Bellanti and certain other people."[29]

Melanchthon reached two important conclusions in his defense of theoretical and practical astrology. First, in response to the criticism that astrological judgments could be wrong, it was only necessary to acknowledge that theoretical astrology, like theoretical medicine, was a fallible, human art that could predict some events with probability, but not all. This was no different from what Ptolemy had claimed about the prediction of particulars in the *Tetrabiblos*.[30] It was also consistent with Melanchthon's Stoic definition of an "art" as a teaching or collection of certain propositions that offer a certain utility—but not absolute certainty—in life.[31]

When Melanchthon returned explicitly to Pico's main arguments against divinatory astrology in the *Initia Doctrinae Physicae*, he reached a second, important conclusion concerning the question of whether and how astrology can explain particulars. Specifically, Aristotle had not adequately justified the connection between universal cause and specific effects: "Aristotle says: 'The astrologers seek out particular effects—some many, others fewer—how one or another motion of the stars affect various qualities [of matter].' But Aristotelian physics passes over this doctrine concerning the particular effects of the stars, remaining content with a general forewarning, that the heavenly bodies are the universal, efficient cause that incites and tempers matter by means of motion and light."[32]

In a later section on physical fate, Melanchthon confronted Pico's important objection that for astrology to be a science would require replication of identical cases. Pico had argued that even if the astrologer knows the exact configuration of the heavens at the moment of a man's birth, the same groupings or alignments never return or do so only after thousands of centuries. If the astrologer limited his observations only to the most frequently recurring configurations, Pico objected, his observations would be imperfect, because he did not consider the same part in relation to the same group of entities.[33] Against this, Melanchthon argued that because universal causes determine all particulars in nature, astrology, like medicine, needs only a few verified cases to establish that heavenly arrangement A is causally connected with singular terrestrial experience B.[34] However, by "singular experience," Melanchthon actually meant any experience that was a member of a particular class. For example, all children born when the Moon is joined with Mars and Saturn in the sixth house are potentially sickly; eclipses generally announce sad events. In other words, Melanchthon defended the prediction of singular events of a sort to be found in the annual prognostications and the *Centiloquium*, where certain arrangements of celestial bodies caused certain classes of terrestrial events.

That Melanchthon ignored Pico's attack on the uncertain order of the heavens should probably evoke no surprise. The main worry came from the threat to the causal nexus between heavenly motions and earthly events. This had also been the principal concern of Lucio Bellanti and other opponents of Pico. For Melanchthon, as for these earlier writers, the "precepts of the heavenly motions" were not called into question. Thus, in the *Initia Doctrinae Physicae*, his most systematic statement, Melanchthon treated the science of the heavens unproblematically on the basis of ancient authority: "according to the usual teaching of Ptolemy."[35] In short, he took for granted that there was a consensus among the astronomers.

RHETICUS'S *NARRATIO PRIMA* IN THE WITTENBERG-NUREMBERG CULTURAL ORBIT

G. J. Rheticus, a member of Melanchthon's circle at Wittenberg, wrote the *Narratio Prima* during the first few months of his stay with Copernicus in Frombork between May 1539 and the end of September 1541. Their relationship was undoubtedly a close one: Rheticus had a unique opportunity to become well acquainted with Copernicus in his last years. During Rheticus's stay, he prepared a map of Prussia, a biography of Copernicus, and a treatise arguing that the Earth's motion does not contradict holy scripture. Neither the map nor the biography are extant, but Reijer Hooykaas has recently found and published the important work on scripture.[36] A *Narratio Secunda* or *Altera* is frequently mentioned, although it never appeared. Because of the special opportunity for the older and the younger man to develop a trusting and familiar relationship, the question of authorial responsibility for the *Narratio Prima* remains an important consideration. How much of it reflected Copernicus's own views, and how much those of Rheticus? Indeed, what conventions of joint authorship were operative? Who was the intended audience?

The work did not dissimulate. It was cast in the form of a letter to Johannes Schöner, a real, rather than a fictional, person.[37] Nonetheless, in various places, Rheticus made skillful rhetorical use of Schöner's character as a literary resource to present Copernicus's claims and arguments. As I have already remarked, Schöner was a prominent member of an influential network of humanists and astrological practitioners whose focus was fixed in Melanchthon's Wittenberg. Schöner had studied astronomy with Bernhard Walther at Nuremberg; Walther had acquired the papers of Regiomontanus, and many of these subsequently came into Schöner's possession. From 1526 until the end of his life, Schöner taught mathematical subjects at the Nuremberg *Gymnasium.* Melanchthon had revamped the curriculum at Nuremberg much as he later did at many other *Gymnasia* and academies of Germany. Schöner also had a printing press at his own home in Kircheherenbach, like Peter Apianus's original press in Landschut.[38] Later, he became well-known for having published the bulk of Regiomontanus's literary remains (from 1531 onward), much of it at the Petreius presses in Nuremberg.[39] In fact, Schöner was deeply involved in the revival and consolidation of Regiomontanus's reputation as a great mathematician and astrologer. He mentioned using Regiomontanus's *Tabulae Directionum* in his own astrological calculations. And it was probably Schöner who first informed Rheticus about Copernicus[40] and who undoubtedly represented him as a practitioner worthy of a place in the Regiomontanus pantheon.

Schöner was also a prolific author in his own right, a major contributor to the German literature on the heavens of the 1520s and '30s. From 1515 onward, he published something nearly every year, a veritable torrent of *practicas*, ephemerides, instrument treatises, wall calendars, reports of comets, and general astrological works. Some of these were *canones* or how-to books: rules for constructing and using clocks and astronomical globes, the kinds of instruments for which Nuremberg was beginning to build a reputation.[41] Along with the prognosticator Johann Virdung (at Heidelberg), Stöffler's student Sebastian Münster (at Nuremberg) and Petrus Apianus, Schöner enjoyed a considerable reputation within the imperial territories. He had also amassed a rich library of astral literature. Among its holdings was the copy, mentioned in chapter 3, of Domenico Maria Novara's treatise "De Mora Nati" (On determining the moment of natal conception), in which the Bologna prognosticator referred to Regiomontanus as "my teacher."

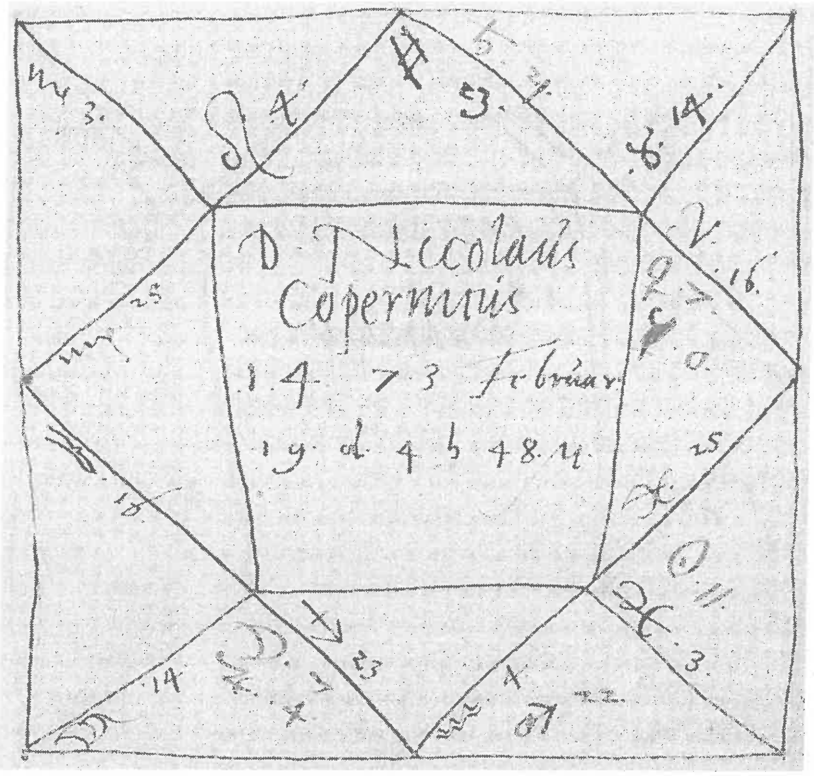
Rheticus arrived in Nuremberg in October 1538, where he spent at least one month with Schöner. From there, Rheticus moved northwest to Ingolstadt, where he visited Peter Apianus, and thence to Tübingen, where he met Joachim Camerarius. There is little doubt that Rheticus's tour of the Nuremberg orbit was motivated by Melanchthon. Melanchthon, Camerarius, and Sebastian Münster had all studied at Tübingen with the flood prognosticator and calendar reformer Johannes Stöffler. Melanchthon probably arranged the trip, perhaps with the hope that the twenty-four-year-old Rheticus could improve his competence as a prognosticator by visiting Schöner. At any rate, as Rheticus narrated in 1542, it was on this trip that "I heard of the fame of Master Nicolaus Copernicus in the northern lands, and although the University of Wittenberg had made me a Public Professor in those [mathematical] arts, nonetheless, I did not think that I should be content until I had learned something more through the instruction of that man. And I also say that I regret neither the financial expenses nor the long journey nor the remaining hardships. Yet, it seems to me that there came a great reward for these troubles, namely, that I, a rather daring young man [*iuvenili quadam audacia*], compelled [*perpuli*] this venerable man to share his ideas sooner in this discipline with the whole world."[42] The reference to expenses, the long journey, and so forth suggests that Frombork was not on the original itinerary, and that the decision to visit Copernicus was made only after Rheticus's southwest journey had begun. This inference suggests that it was not Melanchthon who had referred Rheticus to Copernicus. The decision to dedicate the *Narratio Prima* to Schöner, therefore, was evidently a way of directing that work to Melanchthon and his famous circle of students and followers at Wittenberg.

Astrological interests were undoubtedly foremost in the one-month encounter between Rheticus and Schöner at Nuremberg. We can well imagine that Schöner's *Little Astrological Work, Collected from Different Books* (*Opusculum Astrologicum, ex diversorum libris . . . collectum*), in press with Petreius and due to appear the following year, would have been on the agenda of discussions. This work was typical of the sorts of "collections for the use of the studious" that Petreius was increasingly interested in publishing. It also fitted well into his program of weeding out the "superstitious" Arabic elements from astrological practice. Schöner's *Opusculum* bundled together various works of theoretical astrology. It included his own instructions for reading ephemerides, conveniently tabulated columns correlating planets with relevant terrestrial effects, an introduction to judiciary astrology, "succinct rules of nativities," and "common elections." To these he added the treatise on elections of Lorenzo Buonincontro, an author in some demand,[43] and Eberhard Schleusinger's *Declaration against the Slanderers of Astrology*. Schöner also published a vernacular prognostication for 1539 in Nuremberg, and that too might have been part of his discussions with Rheticus.

It follows that Rheticus and Schöner were interested in Copernicus's work because of its potential value for astrological prognostication, and the same was true for the publisher, Petreius. Moreover, Copernicus already had something of a reputation in Nuremberg for interpreting nativities.[44] Both Rheticus and Schöner had spoken with Petreius about publishing some works by Copernicus in Nuremberg.[45] Immediately after the appearance of the *Narratio Prima* around March, 1540, Petreius wrote a public letter to Rheticus. Significantly, this letter appeared at the head of the text of a fourteenth-century treatise by Antonius de Montulmo titled *De iudiciis nativitatum* (Concerning the judgments of nativities). Petreius surrounded Montulmo's work with symbolic evocations of high cultural authority: the Montulmo manuscript came from the library of a prominent Nuremberger (Schöner); it had a Regiomontanus association (having appeared on Regiomontanus's *Tradelist* of works to be published); the Petreius edition contained annotations attributed to Regiomontanus; and the work was published together with the treatise of a prominent Italian astrologer (Luca Gaurico).[46]

For Petreius, who had himself studied at Wittenberg, this publication was clearly another element in the Melanchthonian program to promote a legitimate Christianized astrology. As he phrased it: "This part of philosophy concerning nativities has sure and great advantages for conducting the course of life properly without superstition."[47] Nonetheless, the businessman Petreius was not entirely averse to publishing works of Arabic astrology if he thought they possessed some utility in promoting the casting of nativities.[48] Likewise, Petreius believed that even though Copernicus's theory departed from "the common explanations by which these arts are taught in the schools," it could still be of great use to "this part of philosophy concerned with nativities."[49] Indeed, it may have been Schöner who cast a horoscope of Copernicus based on information supplied by Rheticus. The horoscope agrees better with Schöner's *Tabulae Resolutae* than with Copernicus's own numbers.[50] Undoubtedly Schöner also believed that Copernicus's work could be of value to various branches of astrology beyond that of casting horoscopes.[51]

The dedication in the first edition of the *Narratio Prima* foregrounded Schöner's reputation and authority: "To that Most Famous Man Johann



32. Copernicus's horoscope, ca. 1540. Courtesy Bayerische Staatsbibliothek, Munich.

Schöner." Apart from the appeal to Melanchthon, the decision to dedicate the volume to Schöner suggests that both Rheticus and Copernicus believed that the association had value in legitimating the new enterprise. Through his numerous publications, Schöner was known to a wide readership for his mathematical and astrological skills and for his association with Regiomontanus. Moreover, at Nuremberg (and hence within the imperial territories) the frontispiece and dedication were of considerable value in publicizing the new hypotheses—perhaps of greater value than having Schöner act, like Andreas Osiander, as an editor or publication facilitator. The title continued: *Concerning the Books of Revolutions of that Most Learned Man and Excellent Mathematician, the Venerable Doctor Nicolaus Copernicus of Toruń, Canon of Varmia.* Throughout, Rheticus addressed Schöner with paternal deference, "as to his own revered father." This deference carried over to Copernicus, who, for reasons that were more than rhetorical, was constantly represented as "my teacher."[52]

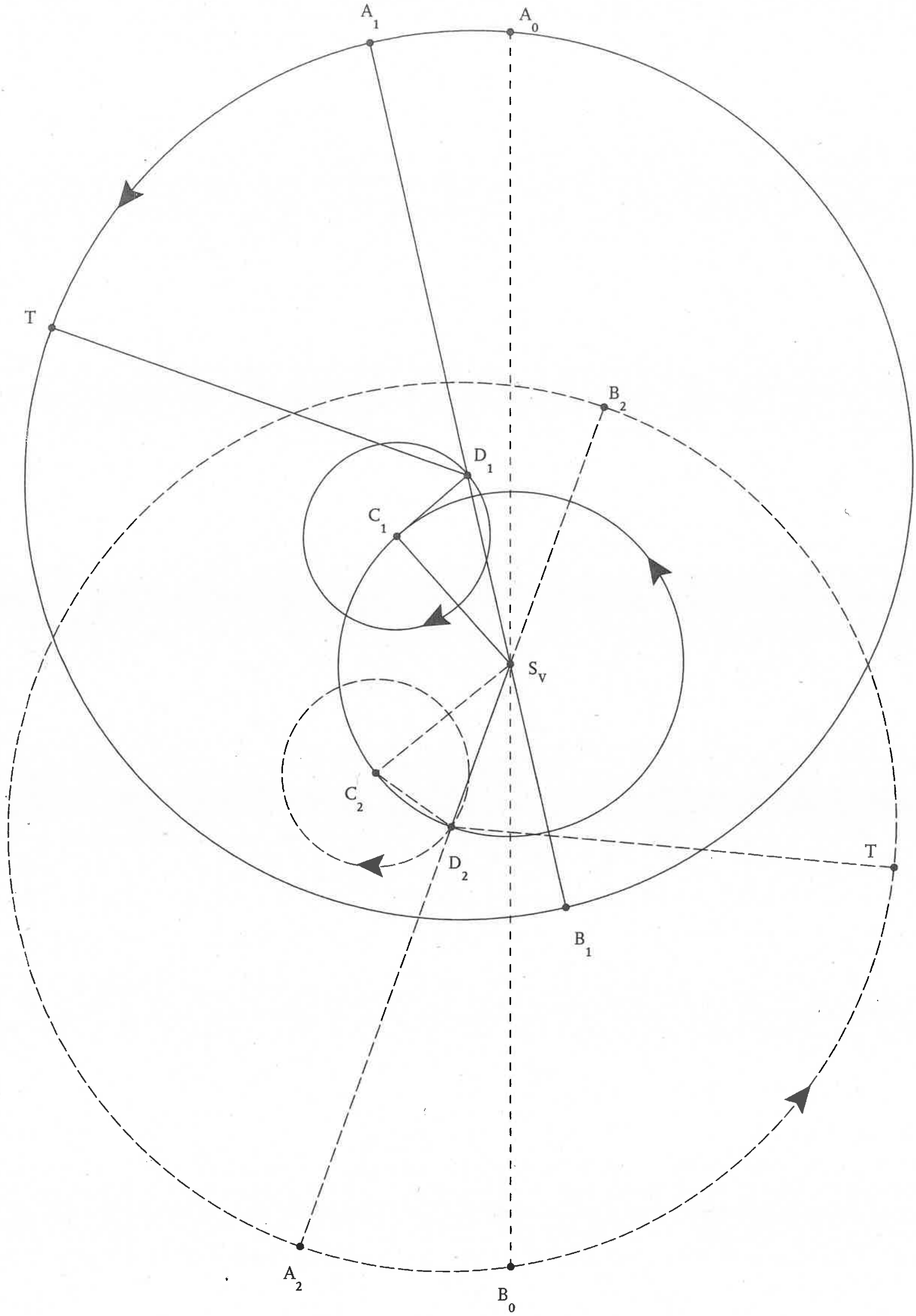
The second issue (1541) was also a product of palpable Wittenberg-Nuremberg associations. It contained a new foreword by Achilles Pirmin Gasser, who knew Rheticus well from their hometown of Feldkirch. Gasser had typically wide humanist interests and skills. Like Rheticus and Petreius, he had studied at Wittenberg; he also held a medical degree from Montpellier and had followed Rheticus's father as city physician of Feldkirch.[53] He wrote five brief reports (*Unterrichten*) on the plague and an equal number of short "descriptions" (*Beschrybungen*) and "reports" on comets that appeared in 1531, 1532, 1533, and 1538.[54] In 1538, Melanchthon dedicated to Gasser an edition of John of Sacrobosco's *Libellus de Anni Ratione,* in which he also praised Rheticus. The following year Gasser published *Elementale Cosmographicum* at Strasbourg, a short work treating the "rudimenta" of astronomy and geography.[55] Between 1543 and 1545, Johannes Petreius published four of Gasser's prognostications; the prognostication for the year 1546 is dedicated to Rheticus.[56] Finally, in September 1543, Petreius inscribed as a gift to Gasser a copy of *De Revolutionibus.*[57]

Gasser's reputation as *medicus* and *astrologus,* as well as his prominence in Wittenberg-Nuremberg friendship circles, helps to explain why Rheticus recruited him to add a dedicatory letter to the second edition. Gasser called attention to the book's potential interest for astrological physicians or "iatromathematicians" by addressing a former schoolmate and fellow physician, Georg Vögeli of Konstanz (d. 1542): "So, dear Georg, we see that we are liberated from the majority of difficulties in astronomy and that other more obscure matters are cleared up for us, thus I beg you to read this little book that I am sending to you fully and with care; and after you have read it, criticize it rigorously and then recommend it especially to all those who love mathematics, in particular those who are close to you."[58] Gasser left no doubt that this was an unusual book—not merely "new" and "useful," but daring: it went against common sense and against the "theorics" usually taught in the schools. And it had reformist overtones: monks might even declare it to be "heretical." Nevertheless, this was a book that Gasser praised in vivid and unprecedented terms: "It genuinely appears to offer the restoration and even rebirth of a new astronomy that is completely in agreement with the truth; for, with the utmost vigor, it presents propositions most clearly upon those kinds of subjects which, as you know, have been a matter of controversy everywhere on the earth both among the most learned mathematicians and the greatest philosophers as well." According to Gasser, these controversial topics included "the number of celestial spheres, the distance of the stars, the sun's governance [in the universe], the planetary circles and their places, the constant length of the year, knowledge of the equinoctial and solstitial points, and finally the motion of the earth itself [nowhere mentioned in the title] and other difficult topics." Two audiences would find this book of especial value: "learned men of our time" (*ab nostri saeculi eruditis*) and "men moderately trained in mathematics" (*mediocriter mathesi imbutos*), and, of these, especially the "makers of ephemerides" (*ephemeridistas*).[59] Both theoricists and ephemeridists would like this book because astronomy—by virtue of its infallible precision, the surest of the sciences—was troubled by disagreements between observations, times, and what was promised by the models.

The rhetoric of Gasser's appeal to Vögeli mimicked Rheticus's strategy in dedicating his work to Johannes Schöner. Effectively, Schöner functioned as a stand-in for the audience of general readers. The stated purpose of the *Narratio* was both to "explain" and to "convince" Schöner that the ideas of Copernicus were worthy of comparison with the best thinking of the ancients (Ptolemy) and the moderns (Regiomontanus). Rheticus, in turn, presented himself as an earnest and admiring student rather than invoking his official position as a *magister*, a *mathematicus* on leave from the University of Wittenberg. He made a point of saying that he had had but a short time (ten weeks) to master the essentials of "a work of six books in which, in imitation of Ptolemy, he [Copernicus] has embraced the whole of astronomy, stating and proving individual propositions mathematically and by the geometrical method."[60] This passage clearly referred to the work promised by Copernicus in the *Commentariolus*. Rheticus stressed his own intellectual limitations. In addition to the short time available to him, he mentioned a "slight illness" and a "restful" side trip to Lubawa (Löbau) with Copernicus "on the honorable invitation of the Most Reverend Tiedemann Giese, bishop of Kulm." One gains the impression that they spent much time together and that Rheticus was integrated into Copernicus's circle of acquaintances.

The inclusion of so much biographical information suggests a strategic consideration: the creation of a verisimilar representation of the author. Responsibility for any misrepresentations was to be attributed to the fallible young student Rheticus rather than to the ideas of the master Copernicus. And it is possible that this way of structuring authorial responsibility had a conscious objective, namely, to permit stronger, more enthusiastic—perhaps even more controversial—claims to be made on behalf of the heliocentric hypothesis.

The interweaving of autobiography and the order of topical presentation and omission also served a further strategic function. Rheticus said that he had "mastered the first three books, grasped the general idea of the fourth and begun to conceive the hypotheses of the rest." However, he claimed that it would be "unnecessary to write anything to you" about books 1 and 2, "partly because my teacher's doctrine of the first motion does not differ from the common and received opinion."[61] In other words, Rheticus used the excuse of his own limited time to avoid beginning his presentation with the controversial questions of book 1.[62] Later, in spite of these earlier disavowals, he would return to this section of the manuscript. Consciously or not, the reader of the *Narratio Prima* was urged to identify with the author as someone working his way through the master's own work. As a result, the book opened with no hint of the "new hypotheses" to be introduced.



33. Complex modern reconstruction of Rheticus's Wheel of Fortune. The Earth (T) revolves counterclockwise in one sidereal year around D, a point off-center or eccentric to the Sun (S). But eccentric point D, shown at two positions (D_1 and D_2), in turn, revolves clockwise in 3,434 years around the small circle (or epicycle) with center C, shown at two positions (C_1 and C_2) as C revolves about fifteen times more slowly than D counterclockwise around the true Sun (S). Rheticus's Wheel of Fortune is designated as the circle centered on point C because its motion controls the Earth's maximum (A_1, A_2), minimum (B_1, B_2), or mean (not marked) distances from the Sun, and Rheticus believed that such changes in the Earth's eccentricity governed the times when great empires (Rome) and religions (Islam) would rise and fall. He also believed that the motion of D "did not differ much" from Elijah's prophecy of six thousand years for the second coming of Christ (i.e., 1¾ revolutions: 3,434y+2,575y = 6,009y). From Rheticus 1982, 153–55. Courtesy of the editors.

Rheticus then devoted the first seven chapters of the *Narratio* to the sorts of astronomical issues that would be of direct interest to astrological prognosticators like Schöner: topics underlying the stability and accuracy of the calendar, such as the motions of the fixed stars, the problem of the lengths of the tropical and the sidereal year, changes in the obliquity of the ecliptic, variations in the eccentricity of the solar apogee, the lunar theory, and eclipses. These are precisely the highly technical subjects that Copernicus addressed at great length in books 3 and 4 of *De Revolutionibus.*

WORLD-HISTORICAL PROPHECY AND CELESTIAL REVOLUTIONS

Rheticus then broke with generic convention. He departed from his autobiographical asides, from descriptions of the mechanisms of theoretical astronomy, and, unbeknownst to his readers, from Copernicus's manuscript. He introduced chapter 5 very simply: "I shall add a prophecy: That the Kingdoms of the World Change with the Motion of the Center of the [Earth's] Eccentric." He did not say, "*My teacher* adds a prophecy." So we can presume that Rheticus and Copernicus had decided to keep prophecy making in Rheticus's domain. But even if we grant that the idea did not originate with Copernicus himself, it cannot be the case that Rheticus "added" the prophecy without Copernicus's permission.[63] Rheticus stayed with his mentor for over a year after the publication of the book. And there is no evidence that Copernicus in any way objected to its contents, as the second edition appeared with some minor changes to the title but none to the text.[64] Moreover, although the prophecy has worried some modern commentators by appearing to interrupt the discussion of the eccentric's motion,[65] the marginal chapter designations added by Rheticus's secretary, the geographer Heinrich Zell (1518–68), allay this concern: Zell's side notes did not mark this section as a *digressio*. Hence there is no doubt that Rheticus meant the previous discussion to be continuous and hence to establish the astronomical basis for the prophecy.[66]

The kind of prophecy under discussion is also important. Rheticus used the word *vaticinium*. Significantly, he did not choose the terms that he deployed in a later vernacular forecast: *Prognosticon oder Practica Deutsch.*[67] Nor did he use the occasion to write a general oration in praise of astrology—the topic of his master's disputation in 1535.[68] The reason for this choice of language is obvious once we look more closely at what he was doing in the *Narratio:* "We see that all kingdoms have had their beginning when the center of the eccentric was at some special point on the small circle . . . it appears that this small circle is in very truth the Wheel of Fortune, by whose turning the kingdoms of the world have their beginnings and vicissitudes. For in this manner are the most significant changes in the entire history of the world revealed, as though inscribed upon this circle." This was an apocalyptic, world-historical prophecy rather than a prognostication for the coming year. It began with the Roman Empire (at the Earth's maximum eccentricity) and then, as the eccentricity diminished, Rome declined "as though aging, and then fell." When the eccentricity reached the quadrant of mean value, the "Mohammedan faith" came into being and with it another great empire. Rheticus prophesied that in one hundred years, at minimum eccentricity, "it will fall with a mighty crash." The return of the eccentric's center to the other boundary of mean value, where it was at the world's creation, would herald the return of Jesus Christ. "This calculation," Rheticus added, "does not differ much from the saying of Elijah, who prophesied [*vaticinatus est*] under divine inspiration that the world would endure only six thousand years, during which time nearly two revolutions are completed."[69] In other words, knowing exactly the revolutions of the Wheel of Fortune eccentric allowed one to interpret the celestial cause properly and, hence, the meaning of the prophecy of Elijah.

The Elijah prophecy was very well known and much commented on when Rheticus composed these words.[70] One of the key eschatological texts of the thirteenth-century Joachimite prophecies was undoubtedly operative: "Helias cum veniet restituet omnia" (When the Messiah arrives, all will be restored).[71] But when in world history would the Messiah come? At Wittenberg, the *Chronicle* of Johannes Carion became the principal text for interpreting the meaning of the four monarchies and the Elijah prophecy. The entire work was organized into three books, following the three periods of world history allegedly prophesied in the saying of Elijah. In 1550, it was rendered into English:

The worlde shall stande syxe thousand yeares and after shall it falle.
Two thousand yeares wythout the Lawe.
Two thousande yeares in the lawe.
Two thousand yeares the tyme of Christ.
And yf these yeares be not accomplyshed, oure synnes shall be the cause, whyche are greate and many.[72]

Many other chronologies, such as those of Achilles Pirmin Gasser, were modeled on this tripartite structure.[73] The *Chronicle* claimed to reveal God's plan as the master narrative of world history, the key to understanding the biblical prophecies. The heavenly revolutions were part of this divine plan and helped to explain particular fortunes and misfortunes in the larger scheme of sacred and profane history. With good reason, Robin Barnes contends that the *Chronicle* was "the main vehicle for the entry of the latter [Elijah] scheme into Reformation thought."[74]

Melanchthon and Johann Carion had both studied with Stöffler at Tübingen; later, Carion became court astrologer to the elector of Brandenburg. Melanchthon rewrote Carion's manuscript, with assistance from Caspar Peucer, who prepared for Wittenberg students a large fold-out table of the book's topics. The two detailed volumes of the rise and fall of kingdoms and rulers appeared in at least one English and fifteen German editions before 1564 and, after 1558, in various Latin editions.[75] Melanchthon also connected the Elijah prophecy explicitly to the study of astronomy in his *Oratio de Orione:* "The opinion attributed to Elijah should not be condemned: the world will last 6,000 years, and then, after that, there will be a conflagration. 2,000 years of idleness; 2,000 years of Law; 2,000 years until the days of the Messiah."[76] And Luther gave prominence to Elijah's prophecy in his *Supputatio Annorum Mundi* (Wittenberg, 1541), a great, biblically derived chart of world history, modeled on analogy with the six days of creation. Luther estimated that Christ had been born when the world was 3,960 years old—not quite in agreement with Elijah's figure of 4,000—and that by his own time in A.D. 1540, some 5,500 years had elapsed.[77]

Reformation prophesiers freely appropriated exegetical resources from pre-Lutheran authors. Ironically, the Wittenbergers owed much to Pico della Mirandola before his skeptical period: he discussed the Elijah prophecy at length in his Genesis treatise, the *Heptaplus*.[78] As Rheticus certainly knew the *Heptaplus* directly, it is possible that Copernicus was also familiar with it.[79] According to Pico, Elijah's prophecy pertained to the fourth day of Genesis, that is, the fourth millennium after the Creation. Quoting the Hebrew text, Pico translated as follows: "The sons or disciples of Elijah said: six thousand years for the world; two thousand empty, two thousand for the law, and two thousand for the day of the Messiah, and because of our sins, which are many, there have passed those which have passed."[80]

These numbers left some exegetical difficulties for Pico. Against the "Hebrew interpreters," he argued that the period from Adam to Abraham was only 1,848 years: "Thus it came about that the fullness of the law succeeded the emptiness not after the second millennium but within its limits."[81] Likewise, Christ appeared 3,508 years after the beginning of the world—hence, within the limits of the fourth millennium rather than after its limits had passed.[82] Pico thus represented a pre-Reformation, Catholic alternative to Carion's estimate for the time of Christ's arrival. He concluded that the Catholic Church appeared just as does the "light of the moon" and that it shines on the world with a "countless multitude of martyrs, apostles, and doctors who all became famous within 500 years after the death of Christ."[83]

These learned reckonings about Christ's return help us to appreciate a further reason why Rheticus and Copernicus chose to call their work the *First Narration concerning the Books of Revolutions,* and why the masterwork itself was called *Six Books concerning the* Revolutions *of the Celestial Orbs*.[84] Knowledge of the proper periods of heavenly revolution permitted one to understand and forecast not merely annual and local terrestrial effects but also *longue durée,* biblical, and world-historical consequences. Indeed, at the end of his brief interpretation of the Elijah prophecy, Rheticus addressed Schöner: "God willing, I shall soon hear from your own lips how it may be inferred from great conjunctions and other learned conjectures of what nature these empires were destined to be, whether governed by just or oppressive laws."[85] The book's audience, in other words, was invited to draw further connections between the new solar model, the qualities of rising and falling empires, and the second coming of Christ. Yet, in view of the sensitive authorial arrangement—a Lutheran author narrating the astronomical hypotheses of a Varmian canon—it is also understandable why there could be no mention of the Melanchthon-Carion, antipapist reading of world history.

After Copernicus's death, however, Rheticus continued to develop further entailments of astrology and scripture, as for example in his preface to Johannes Werner's *On Spherical Triangles* and *On Meteoroscopy:*

> We know that the stars govern things below according to the order of nature, but the Creator of the heavens, who calls the stars by their name and who prescribes their measure and limit, who causes them to stop in their paths whenever he wishes, governs the effects of the stars as he wishes. Equally, through Joshua, he stopped the Sun in the sky, and through Ezekiel he caused it to reverse its path. But, as far as the stars are concerned I have no doubt that for the Turkish empire there is impending disaster, momentous, sudden, and unforeseen, since the influence of the Fiery Triangle is approaching, and the strength of the Watery Triangle is declining. Moreover, the anomaly of the sphere of the fixed stars is nearing its third boundary. Whenever it reaches any such boundary, there always occur the most significant changes in the world and in the empires, according to historical reports. And it is at this moment that God has exercised his judgment and that he has deposed the powerful from their thrones and lifted up the lowly—which happened to Xerxes when he invaded Greece with his large army.[86]

Immediately following this passage, Rheticus added a revealing remark: "Nicolaus Copernicus, the never sufficiently praised Hipparchus of our century, was the first to discover the law of the anomaly of the orb of the fixed stars, as we explained long ago. For when I had traveled to Prussia, for about three years, just as I was about to depart, this remarkable old man exhorted me to try to bring to perfection that which he himself had the means to bring to perfection, but which he had been prevented from doing by virtue of his age and destiny."[87]

From this passage, it seems quite clear that Copernicus saw in Rheticus a person who could complete the great reform of the science of the stars initiated by Regiomontanus and carried forward by himself. It was Copernicus's "destiny" to reform astronomy, the theoretical part of the heavenly disciplines that concerned the calculation of the revolutions. Now that Copernicus was an old man, Rheticus saw it as his fate to carry on with a reform of the practical parts of astronomy, trigonometry, and the tables of motions, and perhaps also astrological theoric, the equivalent of the *Tetrabiblos*. Here, one should recall again Rheticus's chastisement of Pico for impugning both astronomy and astrology—a mistake that allegedly he would not have committed had he lived to witness Copernicus's achievement. Rheticus placed this triumphant comment just at the end of the "prophecy" passages in the *Narratio*.[88]

CELESTIAL ORDER AND NECESSITY

The first published statement of Copernicus's heliocentric theory occurred, almost inconspicuously, one-third of the way through Rheticus's *Narratio* (at the end of chapter 7).[89] "It is assuredly a divine matter," wrote Rheticus, "that the sure explanation of the celestial phenomena should depend on the regular and uniform motions of the terrestrial globe alone."[90] The placement of this announcement so late in the text differs considerably from the structure of *De Revolutionibus*, where Copernicus introduced the principal claim in the preface and built his case systematically in the first ten chapters of book 1. The difference may be accounted for by considering that Rheticus's rhetorical strategy was directed to the Wittenberg network rather than to a papal audience: first he recommended Copernicus's astronomical improvements, then he associated these with a world-historical prophecy, and only then did he begin to develop the case for connecting those benefits of the new astronomy with a new celestial order.

The new hypotheses were finally introduced and defended (in chapters 8–10). The strategy now drew the reader directly into the scene of persuasion. Again, Rheticus used biographical narrative to create an atmosphere of verisimilitude. He presented to Schöner the reasons alleged to have persuaded Copernicus himself to depart from the hypotheses of the ancients (chapter 8 was titled "The Principal Reasons Why the Hypotheses of the Ancient Astronomers Must be Abandoned"). He then asked Schöner whether the reasons that persuaded Copernicus might be taken to be good reasons (titling chapter 9 "Transition to the Enumeration of the New Hypotheses of Astronomy as a Whole").

Chapter 8 is especially interesting because Rheticus there engaged in some of his most aggressive claims on behalf of Copernicus's hypotheses. Some of these involved the appearance of necessity: things could not be otherwise. This impression was enhanced because Rheticus did not consider alternative explanations. He mixed such allegedly necessitarian arguments together in a list of other reasons that are congruent with the more dialectical or probabilist passages of *De Revolutionibus*. One is tempted to follow the judgment of historians who say that in this case Rheticus had acted alone. But again, I believe that Copernicus would not have allowed such claims to be published had he not agreed with them.[91]

Separate consideration of three arguments helps to show where and how Rheticus tried to bring readers to see persuasive connections between the Earth's motion and other celestial phenomena. First, Rheticus asserted that "the indisputable precession of the equinoxes and the change in the obliquity of the ecliptic persuaded my teacher to assume that the motion of the earth could produce most of the appearances in the heavens, or at any rate, save them satisfactorily."[92] Disagreements about the length of the tropical year were the result not of defective instruments ("as was heretofore believed") but rather of a "completely self-consistent law." If the containing stellar sphere is at rest, then what causes the equinoxes to precess? Rheticus answered that Copernicus discovered that a motion of the Earth was responsible ("or, at any rate, could save the heavenly appearances satisfactorily") and, further, that it was this discovery that "persuaded my teacher to assume" the Earth's motion. Once again, Rheticus used a biographical reference rather than a formal demonstration to promote assent: he wanted Schöner to take notice that Copernicus began to think about, and then to assume, the motion of the Earth in association with the precessional effects. At least one historian, Jerry Ravetz, has even tried to link this passage to Copernicus's work on the calendar and to his discovery.[93]

The second claim was more audacious: "My teacher saw that only on this theory [*hac unica ratione*] could all the circles in the universe be satisfactorily made to revolve uniformly and regularly about their own centers, and not about other centers—an essential property of circular motion."[94] Uniformly revolving circles are an allegedly unique consequence, in other words, of assigning an annual motion to the Earth.[95] This argument immediately evokes the first *petitio* in the *Commentariolus* (although it is noteworthy that Rheticus speaks here of circles rather than of spheres and orbs).[96] Yet, if this claim were logically true—which it is not—then it would make the (equantless) planetary mechanisms a direct result of the assumption of a moving Earth. Again, we may have here a biographical residue, or an eager young man's exaggerated misunderstanding of a theory whose author he admired.[97] In either case, the feature of necessity was allowed to stand in the text.

The third reason also involved the assertion of an unwarranted inference. Here, Rheticus used the authority of Pliny to assert that "the planets have the centers of their deferents in the vicinity of [*circa*] the sun, taken as the middle of the universe [*medium universi*]." Still on Pliny's authority, he continued to the placement of Mars: "Mars unquestionably shows a parallax sometimes greater than the sun's, and therefore it seems impossible that the earth should occupy the center of the universe." It is interesting that Rheticus made this weighty assertion without employing the persuasive appeal of a biographical reference to a specific observation made by Copernicus. This is one of the few places in the text where an alleged calculation without reference to an observation plays a prominent role in the discussion of planetary order. Rheticus evidently thought it sufficient to state the matter as a conclusion that Mars's variations in distance "surely cannot in any way occur on the theory of an epicycle" and, thus, "a different place must be assigned to the earth." Over a half century later, Michael Maestlin would endorse Rheticus's statement in his edition of the *Narratio Prima* (1596) on the authority of an observation reported in a letter from Tycho Brahe to Caspar Peucer.[98]

NECESSITY IN THE CONSEQUENT

Apart from these necessitarian gestures, Rheticus followed a tack closer to the strategy employed by Copernicus three years later and immediately available in the copy of Copernicus's manuscript sitting on the desk before him. He presented the new world hypothesis as an assumption that his teacher felt compelled to adopt "as a mathematician" because, in comparison with the hypotheses of Ptolemy, it led to a multitude of true and harmonious consequences. Rheticus now used for the first time a powerful phrase that never appeared in *De Revolutionibus:* "A most absolute system of the motions of the celestial orbs" (*motus orbium coelestium absolutissimo systemate*). Here, Rheticus repeatedly drove home the systematicity of the new celestial hypotheses on the basis of what looks like inference to the simplest explanation. He tried to augment the uniqueness of the case with a variety of rich tropes and dialectical commonplaces that are absent or only hinted at in *De Revolutionibus.*

The first sort of simplicity is the kind obtained when, as with a clock, many effects are derived from a single cause. This is the sort of image that one usually associates with the seventeenth-century trope of God as clockmaker, creator of an economical system of geared wheels. Rheticus, however, did not yet speak with quite the uninhibited confidence of the following century. Like Copernicus, he used humanist-style, rhetorical-dialectical questions to put the reader in a position where the answers to his questions would seem obvious and irrevisable: "Should we not attribute to God that skill . . . ?" "What could dissuade my teacher, as a mathematician, from adopting a theory suitable to the motion of the terrestrial globe?"[99]

Rheticus then tried to make it seem that astronomy's uncertainty and the existence of a rule of celestial order were generally established matters. His teacher realized that the main "reason for all of the uncertainty in astronomy" ("omnis incertitudinis in astronomia causam") was that a certain "rule" (*regulam*) had been ignored. This rule held that "the order and motions of the heavenly spheres agree in an absolute system."[100] For the remainder of this section, Rheticus continually contrasted Copernicus's adherence to this rule and its disregard or violation by the ancients and their successors.

I think that the purpose of this emphasis on order and its rhetorical amplification was to draw attention away from the inability of Copernicus and Rheticus to satisfy Aristotle's standard of necessary demonstration: reasoning that starts from true premises that require no prior justification, rather than dialectical reasoning, which begins from probable premises or commonplace topics ordinarily held to be true.[101] Both Rheticus and Copernicus had opportunity to become acquainted with Aristotle's standard, as it was quite well established in the curricula at Krakow, Bologna, Padua, and Wittenberg.[102] And their (understandable) difficulty in meeting its demands could well explain the *Narratio*'s earlier strained emphasis on presumed features of necessity. Notable Copernicans later in the century, such as Kepler and Galileo, would grapple, sometimes quite publicly, with the matter of furnishing an apodictic proof for the new hypotheses.

Strikingly, Rheticus altogether avoided references to discussions of apodictic proof in the *Posterior Analytics.* He returned again and again to commonly accepted tropes of harmony and order: the phenomena appear to be linked together "as by a golden chain";[103] "the remarkable symmetry and interconnection of the motions and spheres . . . are not unworthy of God's workmanship"; such "relations . . . can be conceived by the mind (on account of its affinity with the heavens) more quickly than they can be explained by any human utterance."[104] And he applied, quite vividly, the metaphor of musical harmony itself: "We should have wished them [the masters of this science of astronomy], in establishing the harmony of the motions, to imitate the musicians who, when one string has either tightened or loosened, with great care and skill regulate and adjust the tones of all the other strings, until all together produce the desired harmony, and no dissonance is heard in any."[105] Rheticus immediately invoked Arabic astronomers to exemplify the consequences of failing to follow this rule. If only al-Battani had followed this common precept, he lamented, "we should doubtless have today a surer understanding of all the motions." In fact, because the widely used Alfonsine tables built on al-Battani, eventually astronomy would collapse altogether. These were the "principal reasons" for abandoning the ancients' hypotheses.

And with this assessment, Rheticus came at last to the Sun's place in the universe. With no explicit reference to Peurbach, he stated that even under the usual principles of astronomy, the celestial phenomena are connected to the Sun's mean motion. Further, the ancients already regarded the Sun as possessed of an important metaphoric status as "leader, governor of nature, and king." But these ancient solar encomia were later ignored. At this point, Rheticus adduced Aristotle as an authority on the Sun—not the *Narratio*'s last favorable reference to him: "How does the Sun accomplish its task [of governing nature like a king]? Is it in the same manner as God governs the entire universe (as Aristotle has magnificently described in his *De mundo*)? Or, does the Sun, in traversing the entire universe so often and resting nowhere, act as God's administrator in nature? This question appears not yet altogether explained or resolved."[106] And who better to decide this question than "geometers and philosophers (on condition that they have a smattering of mathematics)"?

With clear echoes of Regiomontanus and Domenico Maria Novara, this is the first suggestion that the resolution of the problem of celestial order was going to involve a new representation of the conditions of disciplinary authority. Yet there was no claim that the old approach must be entirely rejected—just the role of the Sun: "My teacher is convinced . . . that the rejected method of the sun's rule in the realm of nature must be revived, but in such a way that the received and accepted method retains its place. For he is aware that in human affairs the emperor need not himself hurry from city to city in order to perform the duty imposed on him by God; and that the heart does not move to the head or feet or other parts of the body to sustain a living creature, but fulfills its function through other organs designed by God for that purpose."[107] In this remarkable and inspired image, Rheticus called attention to the very phenomenon noticed by Peurbach: the presence of the Sun's motion as a component of each of the planetary models. Copernicus had shown the efficient cause of this perceived effect in the planets' apparent motions. Equally important, the same cause produced another major consequence: "A sure doctrine of celestial phenomena in which no change should be made without at the same time reestablishing the entire system" ("certam rerum coelestium doctrinam, in qua nihil mutandum, quin simul totum systema . . . restitueretur").[108] In other words, the necessity that failed to be found in the major premise now turned up as a consequent.

Were the reasons that allegedly persuaded Copernicus now sufficient to persuade Schöner and other readers like him? "I interrupt your thoughts, distinguished sir," Rheticus wrote, "for I am aware that while you listen to the reasons [*causas*] investigated by my teacher with remarkable learning and great devotion, for renewing the hypotheses of astronomy, you thoughtfully consider what foundation [*ratio*] may finally prove to be suitable for the hypotheses of the astronomy reborn."[109] This transition seems to hint at the possibility that Copernicus's reasons were not enough, that different authorities and different, perhaps more general sorts of reasons, must be brought to bear. In fact, in chapter 9 ("Transition to the Enumeration of the New Hypotheses for the Whole of Astronomy"), Rheticus began to shift the burden of proof away from Copernicus alone. His main theme was that both astronomy and natural philosophy, as disciplines in their own right, proceed inductively: "In physics as in astronomy, one proceeds as much as possible from effects and observations to principles." Rheticus worked here with a double-edged sword: if astronomy and natural philosophy begin with a study of consequences and then work their way back to first principles, then this procedure should apply to all its individual practitioners, as much to Aristotle and Ptolemy as to Copernicus. Notably absent was the more stringent standard of necessary demonstration from the *Posterior Analytics*. In fact, Rheticus carefully avoided citing any of Aristotle's logical treatises. He presented instead a quite modest and epistemologically restrained Aristotle, as in this passage, where he cited *De caelo*: "Anyone who declares that he must be mindful of the highest and principal end of astronomy will be grateful with us to my teacher and will consider as applicable to himself Aristotle's remark: 'When anyone shall succeed in finding proofs of greater precision, gratitude will be due to him for the discovery.' "[110] Or, again: "If he could hear the reasons for the new hypotheses, he would recognize what he had proved in [his physics disputations] what he had assumed as principle without proof."[111]

Et tu quoque, Ptolemy: "In my opinion, Ptolemy was not so bound and sworn to his own hypotheses that, were he permitted to return to life, upon seeing the royal road blocked and made impassable by the ruins of so many centuries, he would not seek another road over land and sea to the construction of a sound science of celestial phenomena."[112] Here was the familiar Renaissance topos put in the service of a nascent, inductivist image: the smart and reasonable ancients, capable of changing their minds, versus unreasonable, hidebound contemporaries. If both Aristotle and Ptolemy regarded astronomy as *revisable* knowledge, then someone who came along with better explanations of the phenomena should prevail.

In the opening of chapter 10 ("The Arrangement of the Universe"), it is again Aristotle's authority that grounds the relationship in a weaker logic of relevance rather than a stronger one of causal necessity between hypothesis and results: "Aristotle says: 'That which is the cause of truth in the derived effects is the most true.'" This dialectical approach, echoed later in *De Revolutionibus*, would do much work for both Copernicus and Rheticus. In later sixteenth-century discussions, it turned out to be the point of greatest logical vulnerability, because many writers easily recognized that it was logically valid for a true conclusion to be derived from false premises. Yet Rheticus was quite firm about Copernicus's pattern of reasoning: he has "assumed such hypotheses as would contain causes capable of confirming the truth of the observations of previous centuries" as well as "all future astronomical predictions of the phenomena."[113]

In chapter 10, however, the phenomena were all qualitative. Rheticus engaged in brief, but close, paraphrases of *De Revolutionibus* book 1, chapters 6, 8, and 10, which covered the fixed, outermost sphere, the "common measure of the planetary orbs" ("communis orbium planetarum inter se dimensio"), the magnitude of the universe as "truly similar to the infinite," and "the remarkable symmetry and interconnection of the motions and spheres" ("admiranda . . . motuum et orbium symmetria ac nexus"), as compared with the arbitrary ordering of the "common hypotheses."

At times, the explications were clearer—or, at least, fuller—than the treatment of comparable topics in *De Revolutionibus*. For example, Rheticus wrote that "the orb of each planet advances uniformly with the motion assigned to it by nature and completes its period without being forced into any inequality by the power of a higher orb."[114] This passage makes it evident that there was another account with which Rheticus was arguing—perhaps Achillini's version of the Eudoxan-Aristotelian celestial physics—in which the outermost spheres communicate motion to the lower.[115] In *De Revolutionibus* book 1, chapter 4, however, Copernicus wrote more tersely and was less inclined to display alternative possibilities. At other times, Rheticus introduced suggestive speculations that find no comparable treatment in *De Revolutionibus:* for example, "The larger orbs revolve more slowly, as is proper, whereas the orbs that are closer to the sun, which may be said to be the source of motion and light, revolve more swiftly."[116]

Most prominently, at the end of chapter 10, Rheticus speculated on the cause of there being only six planets. The concern may well have been his alone, as it is not attributed to "my teacher." The early Lutherans, as we have seen, were deeply preoccupied with both the beginning and the end of the world. They were obsessed with the unfolding of prophecy through world history, with all kinds of natural signs of the end of time. If Rheticus regarded the motion of the Earth's eccentric as governing the Elijah prophecy, then he must have seen in the Copernican celestial order the effects of divine planning. However, Rheticus considered the celestial harmony (*harmonia coelestis*), that is, the "entire system" (*totum systema*), to be the consequence but not the cause of there being six planets. Because, for Copernicus, the Moon no longer counted as one of the planets, it was the only remaining body whose center of revolution was the Earth. Rheticus proposed that the number six "is honored beyond all others in the sacred oracles of God and by the Pythagoreans and the other philosophers. What is more agreeable to God's handiwork than that this first and most perfect work should be summed up in this first and most perfect number?"[117] Evidently Rheticus could not find a biblical prophecy to accommodate to Copernican celestial order that was comparable to the Elijah prophecy earlier associated with the Earth's eccentric. He settled, instead, for a pre-Christian/Pythagorean revelation that further amplified the Pythagorean authority invoked in *De Revolutionibus*.

Here and elsewhere, Rheticus's enthusiasm was palpable—more so than that of anyone else until Kepler. Yet he did not match the "heat" generated by his metaphors and necessitarian claims with an effective didactic apparatus. Considering that he was arguing for a new picture of the world, it is strange that there are no woodcut representations of the "world system"; in fact, Rheticus provided detailed descriptions of quite technical matters but no diagrams at all, let alone moving ones.[118] Although the text was scattered with parameters, Rheticus made no effort to organize and tabulate the distance parameters and eccentricities in a way that could prove immediately useful for computation or pedagogy. Michael

Maestlin later felt the need to add diagrams to his edition of the *Narratio Prima* and to augment Rheticus's text with a separate treatment of the planetary theories to make it more useful for teaching purposes.[119] The work, then, was, as its title indicated, a first exposition of something new. In spite of its clarity and its skillful use of humanist rhetorical resources, it seems unlikely that the *Narratio Prima* was ever intended as a pedagogic text.

THE ASTRONOMY WITHOUT EQUANTS

Theoretical astronomy must describe the world accurately, and it must provide arguments for its claims. But what kinds of arguments? Rheticus wrote rather ambitiously: "The hypotheses of my teacher agree so well with the phenomena that they can be mutually interchanged, like a good definition and the thing defined"—as though the principles that things are few rather than many (simplicity) entailed the world's being this way and no other (necessity).[120] From the start, Copernicus seems to have been driven by a wish for necessity, based on a conviction in the economy of the assumptions. Rheticus strongly articulated the voices of both sides of the explanatory coin—the beauty of the assumptions, the necessity of the consequences. Orbs revolving uniformly about their own centers and propelled by "their own nature"—rather than by contiguous orbs—lay at the heart of the new, "simple" astronomy. Ptolemy's equant circles, on the contrary, involved equalizing motions that produced uniform motion about a point that was neither the center of the universe nor the center of the circle on which the planet revolved.[121] For Copernicus, the equant model was incompatible with a physical principle: all celestial motions are uniform or compounded of uniform, circular motions. This is simply what orbs do. There is no property of impenetrability required to achieve these motions; or, at least, Rheticus and Copernicus mention none.[122] Rheticus repeatedly trumpeted Copernicus's replacement of the equant. Oscillatory, rectilinear motions, such as deviations in latitude and slow changes in the equinoctial points, would be cleverly explained using a combination of two uniformly moving circles.[123] Much of the last half of the *Narratio* was a summary of these matters—what Copernicus later called in *De Revolutionibus* the "demonstrations" of the planetary mechanisms, the geometrical demonstrations long since promised in the *Commentariolus*. What it took Copernicus 133 folios to do in books 3 and 4, however, Rheticus compressed into a few pages.

The Earth, itself a globe, now took over the duties of the "first motion" generated in the old hypotheses by the outermost sphere and the Sun (daily risings and settings). But once a single motion had been ascribed to the Earth—"like a ball on a lathe"—then, Rheticus said, other motions might be ascribed to it.[124] The second motion consisted of the "center of the earth, together with its adjacent elements and the lunar sphere carried uniformly in the plane of the ecliptic by the great circle." Rheticus here described the second motion of the Earth in the manner of the mathematicians, that is, as an assumption. He gave no hint that there were any physical difficulties to be solved until he reached the very last section of the *Narratio*—the rich and suggestive "Praise of Prussia" (*Encomium Prussiae*).

Here Rheticus displayed his humanist credentials, once again adroitly representing Aristotle as a fallible, time-bound human, author of a provisional physics. Setting the scene locally, Rheticus invoked the authority (and the words) of Copernicus's lifelong friend, the Varmia canon Tiedemann Giese. He presented Aristotle not as a scholastic logician of the universities, laying down rules of proper procedure, but as a natural philosopher who had followed the astronomers of his own time. This time- and culture-bound "humanist's Aristotle" was one whose judgment was not fixed but rather subject to criticism and reversal. Aristotle said that he had followed the mathematicians in assuming that the Earth is at the center of the universe. By the same token, Giese believed that now contemporaries too would be compelled to take another look at the "true basis of astronomy": "By returning to the principles with greater care and equal assiduity, we must determine whether it has been proved that the center of the earth is also the center of the universe."[125] Giese then raised a series of dialectical questions to suggest the direction of new answers: "If the Earth were raised to the lunar sphere, would loose fragments of Earth seek, not the center of the Earth's globe, but the center of the universe, inasmuch as they all fall at right angles to the surface of the Earth's globe? Again, since we see that the magnet by its natural motion turns north, would the motion of the daily rotation or the circular motions attributed to the Earth necessarily be violent motions? Further, can the three motions, away from the center, toward the center, and about the center, be in fact separated?"[126]

Were these Copernicus's questions as well? Rheticus did not explicitly ascribe them to "my teacher," and the *Encomium* itself ended a few lines later. But it is difficult to believe that such criticisms of Aristotle were those of Rheticus and Giese alone. Rheticus wrote his treatise in the space of ten weeks; Copernicus had been thinking about these problems for at least three decades. Using the humanist strategy of posing rhetorical questions, the questions Giese posed were ideal for student academic disputations and, after the republication of the *Narratio Prima* in 1566, they undoubtedly provided an important heuristic for second- and third-generation Copernicans.

PRINCIPLES VERSUS TABLES WITHOUT DEMONSTRATIONS

Rheticus's *Encomium Prussiae* contains what appear to be the residues of a debate about how the new hypotheses ought to be presented and to which audiences they ought to be directed. Those considerations alone raise the suspicion that much conscious strategizing preceded the book's appearance. Indeed, it helps to explain why there were two quite different presentations of Copernicus's views.

The *Narratio* was explicitly directed to a Nuremberg astrologer; it made no reference to Melanchthon and Wittenberg. Yet Rheticus suffused his *Encomium* with classical and astrological images of a sort that clearly echoed Melanchthon's own. Using Pindar's Olympian ode, he painted a lofty analogy. Once, the Sun-god Apollo brought forth riches from the isle of Rhodes, previously hidden from the Sun's rays beneath the sea; now, "by an act of the gods, Prussia passed into the hands of Apollo, who cherishes it as once he cherished Rhodes, his spouse." The progeny of Prussia and Apollo are its great cities, its great laws, councils, and literature, and its great men: Königsberg (which produced Albrecht, duke of Prussia, margrave of Brandenburg); Toruń (Copernicus); Gdańsk (its council); Frombork (Bishop Johann Dantiscus, the head of Copernicus's order); Malbork (the king of Poland's "treasury"); Elbląg (an "ancient settlement where the sacred pursuit of literature is undertaken"); Chełmno (formerly Kulm; "famous for its literature" and the Law of Chełmno, and also the seat of Bishop Tiedemann Giese). The *Encomium* is a poetically veiled praise of all that has preceded, presenting the Prussian Copernicus rising like the once-hidden isle of Rhodes to receive the rays of the Sun, whose true principles he now exposes.[127]

Yet Rheticus presented a moderate and cautious Copernicus, worried about the likely effects that his views would have, especially among natural philosophers. Even though he realized that the observations required new hypotheses that would "overturn" (*eversurae essent*) the old ideas of celestial order and "do violence to the senses" (*sensibus nostris pugnaturae*), Copernicus

> decided that he should imitate the Alfonsine astronomers rather than Ptolemy and compose tables with accurate rules but no proofs. In that way he would provoke no dispute among philosophers; ordinary mathematicians would have a correct calculus of the motions; but true scholarly men trained in the arts, upon whom Jupiter had looked with unusually favorable eyes, would easily arrive, from the numbers set forth at the principles and sources from which everything was deduced. . . . And the Pythagorean principle would be observed, according to which one ought to philosophize in such a way that philosophy's inner secrets are reserved for learned men, trained in mathematics, etc.[128]

Giese, Copernicus's close friend and sympathizer, was represented as urging the full revelation of these "inner secrets." Contrary to the Pythagorean injunction, the new hypotheses should appear in print. Now, of course, "My friends urged me to publish" was a well-known early modern topos. But Rheticus's naming of Giese makes it likely that this was a genuine reference to the discussions at Lubawa in 1539. In Rheticus's text, Giese pushed strongly for the view that, although desirable, Copernicus must present to the world more than an improved calendar for the church and better tables of planetary motion. The language here is emphatic: "His Reverence pointed out that such a work would be an incomplete gift to the world [*imperfectum id munus reipublicae*] unless my teacher set forth the reasons for his tables [*causas suarum tabularum*] and also included, in imitation of Ptolemy, the system or theory and the foundations and proofs upon which he relied to investigate the mean motions and prosthaphaereses and to establish epochs as initial points in the computation of time." The planetary tables must not appear without an account of their underlying assumptions. This must be both a theoretical and a practical astronomy. But Giese thought that this situation was all the more serious because "the required principles and hypotheses are diametrically opposed to the hypotheses of the ancients." In other words, it was a matter not just of giving reasons but of giving reasons more persuasive than the alternative. Giese continued: "Among men capable of speculation [*artifices*][129] there would be scarcely anyone who would hereafter examine the principles of the tables [*tabularum principia*] and publish them after the tables had gained recognition as being in agreement with the truth." There was no place here, he asserted, for the practice frequently adopted in kingdoms, public affairs, and deliberations, "where decisions are kept secret until the subjects see the fruitful results and remove from doubt the hope that they will come to approve the plans."[130]

Giese's voice in the narrative now vigorously took on Aristotle and the philosophers: "After convincing himself that he had established the immobility of the earth by many proofs, Aristotle finally takes refuge in the argument" that the Earth's placement at the center of the universe is an assumption that saves the phenomena.[131] The more learned philosophers (*prudentiores et doctiores*) would recognize that Aristotle had made a contestable assumption (in *De caelo*, book 2, chaps. 13–14)—precisely in opposition to the Pythagoreans—and they would then need to investigate whether Aristotle had really demonstrated that the center of the Earth was also the center of the universe.

THE PUBLICATION OF *DE REVOLUTIONIBUS*

OSIANDER'S "AD LECTOREM"

Andreas Osiander was a prominent leader of the Reformation movement in Nuremberg, theologically headstrong but extremely influential and effective in spreading his views.[132] Various political leaders sought his counsel, among them Albrecht, margrave of Brandenburg-Ansbach (later duke of Prussia), an important prince whom Osiander succeeded in converting to the Reformed view and whose interest in the stars was considerable. Both Rheticus and Erasmus Reinhold dedicated works to him (respectively, *Chorographia tewsch*, 1541, and *Prutenic Tables*, 1551). In addition, Thomas Cranmer, the future archbishop of Canterbury, lived in Osiander's Nuremberg house during a long visit to the Continent for the purpose of soliciting advice about King Henry VIII's pending suit for annulment. The relationship was a warm one: Cranmer eventually married Osiander's niece, Osiander dedicated his *Harmony of the Gospels* (1538) to Cranmer, and the king eventually found a satisfactory legal resolution to his marital difficulties.[133]

Osiander also gave advice on the publication of *De Revolutionibus*. His involvement in that process was no accident, as his authority on civil and religious questions was considerable: Could the children of Anabaptists be forcefully baptized? No, said Osiander, but their parents could be exiled and the children reared and baptized by a Lutheran family. Could one swear an oath "by all saints"? Yes, replied Osiander, because the word *saints* does not refer exclusively to the saints of the Roman Church. Regarding books that could be printed and sold, Nuremberg had a censorship board, and it was said of Nuremberg's citizens that "what Osiander holds and believes, they must also believe."[134]

Osiander was also a respected member of the Nuremberg-Wittenberg friendship circle centered on Melanchthon. He had been involved in Schöner's appointment to the Nuremberg *Gymnasium* in 1526. Schöner named his son Andreas after Osiander. Melanchthon invited him to contribute an "Ornamentum" to Schöner's *Tabulae Resolutae* in 1536, although Osiander did not comply with the request.[135] In March 1540, when Andreas Aurifaber (1512–59) sent a copy of the *Narratio Prima* to Gasser, he sent another copy to Osiander, his future father-in-law.[136] Between 1543 and 1546, Petreius published five works by Osiander.[137] All of these contacts suggest that Rheticus's decision to entrust the manuscript of *De Revolutionibus* to Osiander must have had something to do with the esteem in which Osiander was held by Melanchthon, Schöner, Petreius, and even Copernicus himself.

Most important, when Osiander received the manuscript at Nuremberg—some time after Rheticus left for a new post at the University of Leipzig in October 1542—his knowledge and perceptions of the new hypotheses had already been shaped principally by reading the *Narratio Prima*.

Hence Osiander would have been familiar with the earlier strategic discussions (reported in the *Encomium Prussiae*) among Giese, Rheticus, and Copernicus concerning theoretical principles versus practical tables without demonstrations. He would have known, as well, that Giese had pushed for the stronger of the two positions. If he knew the second edition, then he would have been familiar also with Gasser's judgments about the "restoration of the most true astronomy."

Just one month after the second edition appeared, Osiander wrote to both Rheticus and Copernicus regarding the presentation of *De Revolutionibus*. Fragments of these letters, written on the same day (April 20, 1541), later came into Kepler's possession and are known only through his excerpts.[138] They show that Osiander was already pushing privately for the skeptical view of astronomical knowledge that he would later articulate in his anonymous "Letter to the Reader." The discussion was, in part, strategic, intended to forestall criticisms. Osiander wrote to Copernicus that something could be done to placate the "peripatetics and theologians whose future opposition you fear." Because Osiander himself was a theologian, perhaps Copernicus and Rheticus had initially sought his personal advice on this matter. But Osiander's counsel was not motivated so much by his own fear of opposition as by what he himself believed about hypotheses and about the proper organization of the domains of knowledge. "I have always felt," wrote Osiander to Copernicus, "that [hypotheses] are not articles of faith but rather foundations of calculation, so that it matters not at all whether they be false so long as they display exactly the phenomena of motion. . . . For this reason, it would be desirable if you would touch upon something about this matter in the preface."[139]

Osiander the preacher believed that theology concerns itself with "articles of faith," astronomy with "foundations of calculation." Hence astronomy can operate quite well from false premises. Moreover, as Osiander told Rheticus even more fully in the second letter, "The Peripatetics and Theologians will easily be placated if they hear that there can be different hypotheses for the same apparent motion and that these [of Copernicus] are not presented because they are certain but, rather, because they permit the most convenient way to calculate the apparent and compounded motions; and, it is possible that someone else may contrive other hypotheses so that to explain the same apparent motion one person may present suitable mental images (*imagines*), another even more suitable; and, each one is free—even better: each should be thanked—if he contrives even more convenient hypotheses." Osiander then added his opinion about how such a form of presentation could induce gradual assent: "In this manner, induced to leave behind their severe critique in order to pass over to the pleasures of investigation, first they will become more reasonable; then, after they have sought in vain, they will come over to the author's opinion."[140]

When *De Revolutionibus* appeared two years later, it contained Osiander's views, placed anonymously in the form of a polemical "Ad Lectorem" ("Letter to the Reader") immediately after the frontispiece, and without the permission of either Rheticus or Copernicus. Osiander had shown the same independence in this matter as he had in the theological controversies in which he was embroiled and which eventually caused him to fall into disfavor in Nuremberg.[141] The "Ad Lectorem" made no direct reference to the *Narratio Prima*, but Osiander clearly presumed the existence of that work when he began it as follows: "Since the novelty of the hypotheses of this work has *already* been widely reported."[142] Immediately, the letter took on a sustained, argumentative tone that echoed what is known from the prior correspondence. The overriding theme was the reassurance that the work would not disrupt the presumed hierarchy of the disciplines: "learned men" need not fear that "the liberal arts established long ago upon a correct basis" will be "thrown into confusion." The higher disciplines of theology and philosophy seek to know the causes of things; in fact, they seek to know true causes, although "neither of them will understand or state anything certain, unless it has been divinely revealed to him." Astronomy, on the other hand, is incapable of finding true explanations: "For these hypotheses need not be true nor even probable; if they provide a calculus consistent with the observations, that alone is sufficient." Osiander offered here his only example of astronomy's limited epistemic capacity: the perplexing relationship between the size of Venus's epicycle and the planet's apparent diameter.[143] Rheticus had mentioned Venus's epicycle as an example of the "vast commotion" stirred up by the opponents of astronomy—a problem now solved by Copernicus's hypotheses![144] And hence Osiander's reference was probably not the least cause of his anger when he read the illicitly attached letter.[145]

The more profound source of Rheticus's ire, however, was Osiander's view of astronomy as a discipline fundamentally incapable of knowing anything with certainty. For Rheticus, this extreme position surely must have resonated uncomfortably with Pico della Mirandola's attack on the foundations of divinatory astrology. And, in fact, Osiander was as deeply familiar with Pico as were most of his learned contemporaries—indeed, not merely familiar, but sympathetic. Unlike the naturalistic reformer Melanchthon, his protégé Rheticus, and the canon Copernicus, it would seem that Osiander now offered new grounds for endorsing Pico's conclusions: not merely was the disagreement among astronomers grounds for mistrusting the sort of knowledge that they produced, but now Osiander proclaimed that astronomers might construct a world deduced from (possibly) false premises. Thus the conflict between Piconian skepticism and secure principles for the science of the stars was built right into the complex dedicatory apparatus of *De Revolutionibus* itself.

Osiander's view of astronomy's limited epistemic capabilities was not at all inconsistent with his attitude toward prophetic speculation about the Last Things. It was desirable to try to reckon the time of Christ's coming for the spiritual comfort it might afford, but such reckoning was ultimately conjectural and speculative. In 1544, the publisher Petreius issued Osiander's *Conjectures on the Last Days and the End of the World* just one year after *De Revolutionibus* and four years after Osiander had read the *Narratio Prima*. The *Conjectures* was supposed to carry forward Melanchthon's commentary on the Book of Daniel by offering a more exact calculation of the prophesied epochs. Of the four conjectures, the first dealt with the prophecy of Elijah, the second calculated that 1,656 years had elapsed between Adam and the Flood, the third connected Christ's age on Earth (33 years) with the end of the Church, and the fourth predicted from Daniel that Rome would twice achieve world dominance.[146]

Osiander's conjectures employed neither astronomical nor astrological methods.[147] Indeed, there was no mention at all of Rheticus's interpretation of the Elijah prophecy linking the motion of the Earth's eccentric to the rise and fall of monarchies. If Osiander was willing to entertain any hermeneutic method auxiliary to scriptural exegesis, it was the earlier Christian Kabbalah of Pico della Mirandola: "These conjectures also use Joan picus merandulane in ye yere of our Lord M.CCCC.lxxxvi. & did put up this one among his disputable 90[0] conclusions saying: if there be any humane conjecture of the last time, we may serche & finde it by the most secret way of Cabbalist, the end of the world to come hence of 514 yeres."[148] Pico's willingness to use the Kabbalah while later preserving a strong skepticism about naturalistic divination was coherent with the view, emphasized by Bruce Wrightsman, that Osiander regarded scripture as the only unerring source of truth.[149] Astronomy was useful only insofar as it assisted in improving the accuracy of the calendar or reckoning more precise biblical chronologies.[150] Other than that, it could lay no claim to the truth of statements about the order of the heavens.

HOLY SCRIPTURE AND CELESTIAL ORDER

The role of Scripture at this point is, nonetheless, curious. Osiander was not a literalist with respect to the Bible's language.[151] But if the Bible was not literal in every respect, how could it be said to be a secure, apodictic resource for knowing what moves and what does not? At stake was the relevance—and hence the authority—of a small group of biblical passages that used nouns (*Sun, Moon, stars*) and verbs (*rise, set, move*) allegedly referring to the heavens. Scripture certainly contained no vocabulary drawn from spheric or theorics (e.g., *ecliptic, equinoctial points, right ascension, orb*). But perhaps such categories could be used to make sense of obscure passages. Here again was the central point of contention for the defenders of Christian doctrine: at what point was it appropriate for natural knowledge to be deployed in assisting faith?

Hooykaas's publication in 1984 of Rheticus's lost work reconciling holy scripture with the motion of the Earth now allows important progress to be made in understanding this problem. To begin with, the exact title of the work is, unfortunately, unknown. However, an important letter from Giese to Rheticus refers helpfully to "the little work by which you have skillfully protected the motion of the Earth from disagreement with the Holy Scriptures."[152] The designation *Opusculum quo a Sacrarum Scripturarum dissidentia Telluris Motus vindicatur* is a more plausible title for the work than either the inscription on the title page ("Epistola de Terrae Motu") or the heading ("Dissertatio de Hypoth. Astron. Copernicanae") chosen by the seventeenth-century Utrecht publisher Johannes van Waesberge. For one thing, the work is not cast in epistolary form; for another, Rheticus never refers to "Astronomia Copernicana," a decidedly seventeenth-century rendering with overtones of Keplerian and Galilean language. The dating of the work also affects what we make of it. If, as Hooykaas plausibly speculates, Rheticus wrote the treatise before September 1541—that is, while still with Copernicus in Frombork—then his arguments and interpretations would have been known to Copernicus and could have been communicated easily enough by either Copernicus or Rheticus to Osiander and Melanchthon.[153] As late as July 26, 1543, when Tiedemann Giese received his copy of *De Revolutionibus*, he expressed the hope that Rheticus would attach both his biography of Copernicus and the *Opusculum* (as I shall call it) to all the remaining printed copies. This shows that Giese regarded it as normal to join together genera of a related nature—much like the conventional practice of forming collections of astronomical and astrological works. It would also suggest that Giese saw it as appropriate to join the *Opusculum* to the finished *De Revolutionibus* rather than to the preliminary *Narratio Prima*. Also, the fact that there is a separate work devoted to the question of scripture, the Earth's motion having been argued for as a desirable "assumption" in another place, helps to explain why Copernicus referred to the matter only glancingly—if not arrogantly—in the preface to *De Revolutionibus*. Finally, if Osiander was acquainted with this treatise or knew of its contents through conversation or correspondence with Rheticus, then one would have expected at least some response to it in the "Ad Lectorem." But there is no direct evidence that either Osiander or Melanchthon was aware of the *Opusculum*.[154]

The *Opusculum* is remarkable not least because it shows that Rheticus and Copernicus had worked out the basic elements of a systematic defense of the compatibility of scripture with the new hypotheses. They knew that they had a problem. Theologically, the work strives for a moderate stance—separating scripture from natural philosophy and using Augustine as the guiding authority with frequent protestations of catholicity and multiple appeals to traditional authorities.[155] This approach was certainly plausible for a Lutheran such as Rheticus, but in practice it might not have satisfied Melanchthon's providential and strongly scripture-driven natural philosophy. For this reason, with an eye on Melanchthon, Rheticus may have had justifiable reasons for hesitating to publish it. Giese's role in urging its publication suggests that the approach was more acceptable to the moderate middle ground of Varmian Catholicism than to the polemical Lutheranism of Osiander or even the theophanic naturalism of the *Praeceptor Germaniae*. Had Copernicus lived, therefore, he might have encouraged the publication of Rheticus's work—as did his fellow canon, Giese. With Copernicus's death on the eve of the Council of Trent (1545–63), this brief gesture of philosophical and exegetical openness would go unheeded until second- and third-generation Copernicans independently revived Saint Augustine's principle of accommodation more than a half century later.

The essence of Rheticus's argument was its appeal to this more flexible Augustinian standard. Among other things, accommodation allowed a separation of the requirements of confessional allegiance from the freedom to philosophize.[156] This method permitted the interpreter to say that in those (few) places where the Bible speaks of natural things, it does so according to common speech. In Rheticus's apt terms: "It borrows a kind of discourse, a habit of speech, and a method of teaching from popular usage."[157] The Bible's purpose determined its discourse—salvation and moral lessons, not philosophical or natural-philosophical teaching. Hence Rheticus urged what amounted to an intentional discursive boundary between the Bible and natural philosophy. The Bible may speak in accord with the senses even if what it says is erroneous with respect to what is held in natural philosophy. On certain matters, however, the Church had declared its position long ago and without ambiguity—for example, with the doctrine of the creation. In such cases, it was fair to regard scripture as having a direct bearing on philosophical beliefs not merely because the Bible said so but because the biblical meaning had the endorsement of ancient patristic authority. But in most other cases—for example, the rising and setting of the Sun—passages that appear to teach about Nature are not to be read in the discursive frame of such technical disciplines as *astronomia theorica* and *practica*.

Both the learned and the unlearned, then, may benefit from the Bible's moral lessons, while the philosophically inclined may construct their beliefs on independent natural foundations. The meaning of difficult passages should be sought by textual comparison rather than by introducing separate technical vocabularies, assumptions, methods, categories, and so forth. From this reasoning followed an important *prohibition*. According to Augustine—echoed by Rheticus—it is sacrilegious to overinterpret by trying to "extract" one's own philosophical views from holy scripture. "For Saint Augustine desires that we should never let ourselves be so happy with our own opinion on nature, which we believe to have extracted from the sacred writings, that, when truth has taught us otherwise, we are ashamed to retract, and fight for our own view, as if it were the teaching of Scripture."[158]

For Rheticus, some commentators exemplified Augustinian exegetical caution (esp. Nicholas of Lyra), whereas others violated the prohibition against "rooting out" (*eruendi*) philosophical views from the scriptures held on independent and prior grounds. One of the offenders was the Roman writer Lactantius, "otherwise a man of great learning and eloquence, [but who] ridicules those who claim that the earth is round."[159] The prime offender, however, was Pico della Mirandola:

> Many passages of Scripture could be collected by way of showing that Scripture often accommodates itself to popular understanding, and does not seek exactness in the manner of Philosophers. So, on the authority of Nicholas of Lyra, it was because of the uncultivated state of the people that, in the beginning of Genesis, no mention is made of the air, much less of the element fire, as being beyond the perception of the uneducated. It is clear that for the same reason, except sun and moon, nothing is said in that place of the other planets,—however much Pico in his *Heptaplus* tries to extract them therefrom—not to speak of still other things that are left out in the same place.[160]

Pico's offense in the *Heptaplus* (1489) was consistent with his offense in attacking the foundations of astrology and astronomy in the *Disputationes*, although Rheticus did not explicitly draw the comparison. Pico's desire was to put scripture ahead of natural divination. But while defending the primacy of scripture, Pico painted an esoteric and secluded image of knowledge: he claimed that its meaning was not on the surface but veiled in the depths of its words. This deeper meaning was accessible only to "the few disciples who were permitted to understand the mysteries of the kingdom of heaven, openly and without figures."[161] Otherwise, Christ proclaimed the gospel to "the crowds" in the form of parables. When Moses spoke at the summit of the mountain, the Sun would illuminate his face "wondrously bright," but "since the people with their owl-like and unseeing eyes could not endure the light, he used to speak to them with his face veiled."[162] By what method could one gain access to the "buried treasures" and "hidden mysteries" of the first chapter of Genesis?

The answer for Pico was that one needed the assistance of an independent hermeneutic that could make sense of the symbolic and often highly condensed manifest language of scripture. In short, one needed a fully developed theory of the Creation itself in order to make sense of the Mosaic account. This is just what Pico provided in the *Heptaplus*. The "Second Exposition," in particular, is relevant to Rheticus, as it deals with the celestial world. Here Pico outlined a ten-sphere heaven—seven planets, the sphere of the fixed stars, the ninth sphere "apprehended by reason, not by sense" and the tenth "fixed, quiet and at rest, which does not participate in motion." Pico offered in support a mix of medieval authorities rather than arguments and empirical evidence: Walafrid Strabo and Bede ("Christians") and the Hebrews Abraham the Spaniard ("a great astrologer," also a favorite source in the *Disputationes*) and Isaac ben Solomon Israeli ("the philosopher").[163] Pico then declared that the eight lowest spheres correspond to what Genesis calls "earth." Following this, Pico then "found" the specific terrestrial elements in the sky in two quite different orders: the Moon corresponded to earth, Mercury to water, Venus to air, and the Sun to fire. Then, "in inverse order": Mars corresponded to fire, Jupiter to air, Saturn to water, and the eighth, "unwandering" sphere to earth.[164] This explicitly figural interpretation of the meaning of *earth* created a notable silence that Pico then addressed: "See how he [Moses] has shown us the nature of the moon and the sun figuratively and in a few words. But why is he silent about the rest, when we promised in our proems that he would treat sufficiently and learnedly of all? Why, I say, when he has made mention of the tenth, ninth, and eighth spheres, and also of Saturn, the sun, and the moon, is there not even a word of the four that are left, Venus and Mercury, Jupiter and Mars?"[165]

Here Pico rejected any appeal to the principle of accommodation as an excessively facile refuge: "I cannot without blushing betake myself to it, since I swore that Moses omitted nothing which might make for a perfect understanding of all the worlds." As described in chapter 3, he later rejected any appeal to the "astronomers" and the "astrologers" because of their longstanding internal disagreements. Thus, Pico's solution lay neither within the Bible itself nor in the domain of the natural philosophers and mathematicians: "I believe that yet more deeply hidden here lies a mystery of the ancient wisdom of the Hebrews, among whose dogmas on the heavens this is important: that Jupiter and Mars are included by the sun, and Venus and Mercury by the moon. If we weigh the natures of these planets, the reason for this belief is not obscure, although the Hebrews themselves offer no reason for the doctrine."[166] Because this arrangement does not occur in Genesis, and the Hebrews "offered no reason" for it, the future author of the *Disputations against Divinatory Astrology* supplied his own, astrologically pregnant interpretation:

> Jupiter is hot, Mars is hot, and the sun is hot, but the heat of Mars is angry and violent, that of Jupiter beneficent, and in the sun we see both the angry violence of Mars and the beneficent quality of Jupiter, that is, a certain tempered and intermediate nature blended of these. Jupiter is propitious, Mars of ill omen, the sun partly good and partly bad, good in its radiation, bad in conjunction. Aries is the house of Mars, Cancer the dignity of Jupiter: the sun, reaching its greatest height in Cancer and its greatest power in Aries, makes clear the kinship with both planets. . . . The moon . . . clearly shares in the waters of Mercury, and shows how great an affinity it has with Venus by the fact that in Taurus, the house of Venus, it is so exalted that it is judged to be nowhere more propitious or beneficent.[167]

Pico concluded his association of the elemental qualities and the ordering of the planets with the confident judgment that "Moses has spoken sufficiently so far of the empyrean heaven, the ninth sphere, the firmament, the planet Saturn, and the sun and the moon which represent the rest, suggesting their inclusion to us by his very silence."[168]

These informative passages show us how far Pico had moved between the *Heptaplus* and the *Disputations*. Equally important, however, is the light shed on the position of Rheticus and Copernicus. They shared with Pico the trope of uncovering deep mysteries. Their quest, however, was a mathematical one. And, as such, Copernicus and Rheticus rejected Pico's view that the order of the planets could be found by reading Genesis either *sensu literalis* or *sensu allegorico*.

DE REVOLUTIONIBUS

TITLE AND PREFATORY MATERIAL

If the *Narratio Prima* was directed to an audience of Nuremberg and Wittenberg preachers, prognosticators, natural philosophers, and theologians, Copernicus's preface addressed *De Revolutionibus* explicitly to a Roman ecclesiastical audience. However, although the preface was cast in the idiom of church patronage and reform, it is not the language of office seeking. This is the argument of a man drawing on his richest intellectual resources and hoping to gain support, near the end of his life, for what he thinks to be the intelligibility of the heavens and, by implication, what the Church ought to teach about it. When Copernicus composed the preface in June 1542, two issues of the *Narratio Prima* were in circulation; Rheticus had already left the manuscript with Petreius; and at sixty-nine, the old canon must have sensed that he did not have long to live. A few months later, he lay paralyzed from a stroke, and on May 24, 1543, he died just as the book was placed into his hands, publishing as he perished.

Even before Rheticus arrived, however, Copernicus's ideas already had supporters in Rome at the level of both the papal Curia and the cardinalate court. Paul III's predecessor, Clement VII, had heard Copernicus's new hypotheses described verbally before him. His young secretary, the Bavarian Johann Albrecht Widmanstetter (1506–77), was a brilliant biblical scholar who, in 1555, published the first Syriac edition of the New Testament.[169] It was Widmanstetter who explained the new theory to the pope in the Vatican gardens in 1533 before two cardinals, a bishop, and the pope's physician. In return, Clement presented his secretary with the gift of a Greek manuscript containing several philosophical treatises.[170] Two years later Widmanstetter moved into the service of a recently promoted Dominican cardinal, Nicholas Schönberg (1472–1537), and after Schönberg's death Widmanstetter became a secretary (*Secretarius Domesticus et Familiaris*) to the succeeding pope, Paul III.

In November 1536, Schönberg wrote to Copernicus, urging him to send a copy of his manuscript to Rome and even offering to provide as amanuensis the representative of the Varmian chapter in Rome, Theodoric of Reden. No mention is made of support for publication. Nonetheless, Copernicus understood the proper signs of epistolary display for seeking approval and protection in Rome, and he could easily have interpreted Schönberg's letter as a sign of eventual papal approbation; at the very least, Widmanstetter's continued presence indicated support in the highest curial circles.[171] Copernicus placed Schönberg's letter in *De Revolutionibus* immediately after the title page and just before his own preface to Paul. In this way, he allowed the Dominican Nicholas Cardinal Schönberg to provide the first description of his new "account of the World": "In it you teach that the earth moves; that the sun occupies the lowest, and thus the middle, place in the universe."[172] Thus, when Osiander placed his anonymous "Letter to the Reader" just after the title page and ahead of the cardinal's favorable letter, he was knowingly interfering as much with the author's methodological aims as with his intended strategy for seeking the pope's protection. Rheticus was so incensed by this unauthorized interference that he tried to seek legal redress against both Osiander and the publisher Petreius from the Nuremberg city council—but without success.[173] However, in the insecure days before the existence of laws of copyright, authors lacked legal recourse concerning the integrity of their works.[174]

By the time that Copernicus drafted his preface, however, his curial supporters were no longer around: Pope Clement and Cardinal Schönberg had died. Nonetheless, in deciding to address Paul III (1534–49), Copernicus could not have been unaware of his reputation. The new pope had, like Copernicus himself, a strong humanist training: he had studied at the University of Pisa, he was a poet, he knew Greek, and he was respected for his wide learning.[175] As the former Cardinal Alessandro Farnese, he also came from a wealthy, noble family. He could afford to pay his servants with his own money rather than strictly from ecclesiastical revenues. In 1526–27, his household contained 306 persons.[176] Although we cannot be sure what Copernicus knew about the papal finances, it is likely that he was quite familiar with the idiom in which specific appeals for patronal protection had been made to the cardinal before he became pope. For example, Pomponio, the brother of the prognosticator Luca Gaurico, dedicated a commentary on Horace's *Ars poetica* to Cardinal Farnese that was published in 1504.[177] The text of this commentary would have been written while both Pomponio and his brother were together in Padua with Copernicus. Much later, Girolamo Fracastoro, also known to Copernicus in Padua, dedicated his Averroist *Homocentricorum Siue de Stellis Liber Unus* (Venice, 1538) to Paul III.[178]

In addition, there were appeals to Paul of a more direct, practical nature: Luca Gaurico issued prognostications in 1529 and in 1532 forecasting that Alessandro Farnese would become pope. These successful predictions did eventually result in the desired papal favor. Gaurico found himself a regular dinner companion of the cardinal. Then, in 1543, he presided at an astrological ceremony for the laying of the cornerstone in the Farnese wing of the Vatican Palace. Gaurico calculated the exact hour and zodiacal sign for the event, assisted by the Bolognese prognosticator Vincenzo Campanacci, who "found the proper time on the astrolabe and announced it in a loud voice." Three years later, Gaurico was rewarded with a bishopric.[179] As one might expect, Copernicus's strategy was much closer to that of Pomponio than that of Luca Gaurico. He kept a distinct silence on prognosticatory matters, making no predictions about the pope's health, longevity, or political future, or the best times to make important journeys. Nor were there echoes of Rheticus's millennial prophecy.

The only hint of astrological connotations is the word *Revolutions* in the book's title. Selecting a title entailed deciding among recognizable genres of writing, genres that readers could recognize, that publishers could use to market works, and for which royal or imperial privileges might be granted. (It is understandable that Copernicus could not appropriate the title of Peurbach's well-established school book, the *New Theoric.* It is less clear why he did not think to choose the more Ptolemaic-sounding *New Almagest,* used by G. B. Riccioli in 1651.) The title on which Copernicus finally settled resonated with the conventional medieval association between revolutions and nativities.[180] There was, as far as I know, no generic precedent for a title that linked revolutions and celestial orbs.[181] And, although Copernicus might have connected revolutions and prognostications, he had no new alternative to the *Tetrabiblos.* His immediate disagreement was with the first principles of the *Almagest* on which his work was modeled.

Yet both in his preface and in the suppressed introduction to book 1, Copernicus stressed again and again not the standard Ptolemaic theme (from the *Tetrabiblos*) of astronomy's capacity for certitude at the general level of its mathematical models (compared with astrology's fallibility in making judgments about the unstable physical world) but rather what we now know to be Pico della Mirandola's complaint: the *uncertainty* among traditional astronomers—including the disagreement about the ordering of Venus and Mercury. Copernicus constantly contrasted the beauty and purity of astronomy's subject matter with the "perplexities" and "disagreements" that encumber its hypotheses. Besides disagreements about hypotheses, there was the additional reason that "the motion of the planets and the revolution of the stars could not be measured with numerical precision . . . except with the passage of time." As a consequence, "very many things do not agree with the conclusions which ought to follow from his [Ptolemy's] system." An example of one such entailment is the uncertain length of the tropical year, about which Copernicus cited Plutarch's view that this value had so far eluded the skill of the astronomers. And further: "It is well known, I think, how different the opinions concerning it have always been, so that many have abandoned all hope that an exact determination of it could be found." He then added to this skepticism the further comment that "The situation is the same with regard to other heavenly bodies."[182]

In the preface, Copernicus approached astronomy's uncertainty by means of ironic contrasts. He presented himself as someone worthy of laughter and derision, someone who goes against tradition and whose theories will surely be repudiated. The tone recalls the diffident, yet righteous Saint Socrates of Erasmus's *Godly Feast.*[183] Two ecclesiastic friends, the cardinal of Capua (Nicholas Schönberg) and the bishop of Chełmno (Tiedemann Giese), had repeatedly urged him to publish. They argued that even if his theory appeared to be crazy, "so much the more admiration and thanks would it gain after they saw the publication of my writings dispel the fog of absurdity by the most transparent proofs [*liquidissimis demonstrationibus*]." Finally he had acceded to their entreaties and would "permit it to appear after being buried among my papers and lying concealed not merely until the ninth year but by now the fourth period of nine years."[184] The allusion to a fourfold Horatian waiting period of thirty-six years probably has some truth, as historians have noticed; but, at this point in the text, it is difficult not to take Copernicus's failure to mention the *Narratio Prima* as anything but a conscious omission—part of a deliberate strategy not to mix the dedications to the two audiences.

The first of the traditional "disagreements" to which Copernicus alludes had been anticipated in the *Commentariolus:* it concerned the preferred foundations of theoretical astronomy. Those who use "homocentric circles" cannot get their theories to fit the phenomena absolutely; those who use eccentrics can deduce the phenomena from the arrangements of spheres but violate "first principles."[185] Worst of all, neither tradition can deduce what Copernicus calls "the arrangement of the universe and the sure commensurability [*symmetria*] of its parts."[186] In short, we have an ironic reversal: It is tradition itself that is full of monstrous incoherence and absurdity. And here follows the famous trope to which Kuhn and others have attached so much significance and which allegedly ties Copernicus to Florentine Neoplatonism through Domenico Maria Novara: "With them it is just as though someone were to join together hands, feet, a head, and other members from different places, each part well drawn, but not proportioned to one and the same body, and not in the least matching each other, so that from these [fragments] a monster rather than a man would be put together."[187]

Copernicus's *symmetria* bears some resemblance to the images amplified so enthusiastically by Rheticus, but his source is the unmistakable and forceful opening lines of Horace's *Ars Poetica*—an allusion that Copernicus probably knew to be pleasing to the pope:

> If a painter chose to join a human head to the neck of a horse, and to spread feathers of many a hue over limbs picked up now here now there, so that what at the top is a lovely woman ends below in a black and ugly fish, could you, my friends, if favoured with a private view, refrain from laughing? Believe me, dear Pisos, quite like such pictures would be a book whose idle fancies shall be shaped like a sick man's dreams, so that neither head nor foot can be assigned to a single shape. "Painters and poets," you say, "have always had an equal right in hazarding anything." We know it: this licence we poets claim, and in our turn we grant the like; but not so far that savage should mate with tame, or serpents couple with birds, lambs with tigers.[188]

The central theme emphasized by Horace and noticed by his Renaissance commentators was the principle of "fittingness" or "belongingness." Style must fit its subject, diction its characters; characters must preserve decorum and appropriateness; the beginning must fit the end.[189] Significantly, the audience is the custodian of "appropriateness" and rejects through laughter what it perceives not to agree with nature. What moves or delights or persuades the audience is what makes for good poetry. And it was this rhetorical view of poetry that many Renaissance commentators so appreciated in Horace.

The uses to which Copernicus put the Horatian text were important and unprecedented. First, he tacitly transferred the literary aesthetic ideal of good poetry into the domain of astronomy. Just as one prefers a coherent to an incoherent literary work, so a theory of the planets possessing mathematical coherence (*symmetria, armoniae nexus*) is to be preferred over one that does not. The implication is that such a world picture is not arbitrary, for art imitates nature; hence, a decorous audience will judge such a theory to be true, while shunning as absurd one lacking in *symmetria*. If such an argument did violence to the *Posterior Analytics* by illicitly mixing the subject matters of poetry and astronomy and by rejecting strictly demonstrative knowledge, it was entirely in keeping with humanist commentators on Horace. For example, in 1482 Christoforo Landino, a well-known rhetoric teacher at the Studio of Florence, commented: "Since all art imitates nature, the poet will be laughed at just as the painter will be scorned if he portrays the monstrous, viz. if he places a human head on the neck of a horse and to this horse's neck he paints in the body from the various parts of birds and makes the lowest members those of the fishes."[190]

Copernicus found Horace's image helpful for another reason. It offered a reply to the view of astronomical hypothesis articulated by the likes of Osiander and Fracastoro.[191] Astronomers, like painters and poets, might possess "an equal right in hazarding anything," but even the latter did not have unlimited license to join lambs with tigers and serpents with birds. Copernicus acknowledged "the freedom to imagine any circles whatever"—including his own supposedly absurd hypothesis of assigning an imaginary circle to the Earth "for the purpose of explaining the heavenly phenomena." The beauty and irony of the "absurd" assumption was that, comparatively speaking, it led to "sounder demonstrations" (*firmiores demonstrationes*). Thus, beyond its well-known astrological connotations, the choice of the word *revolutions* in the book's title sought to focus attention on the new astronomical meaning in the multiplicity of desirable entailments that flowed from the putatively absurd conditional premise. And, among those entailments, Copernicus stressed that his hypothesis alone yielded the *symmetria* lacking in rival alternatives: "The order and size of all the planets and spheres, and heaven itself is so linked together that nothing can be moved from its place without causing confusion in the remaining parts of the universe as a whole."[192]

The logic of this claim was relative rather than absolute, and it was the best that Copernicus could offer. It built on the image of weighing and balancing alternative hypotheses against a commonly accepted standard rather than against the stringent Aristotelian ideal of a *cognitio certa per causas*, in which true conclusions, deduced from true, proper, and necessary premises, rule out all possible alternatives.[193] Copernicus thus brought forward humanist rhetoric and dialectic as an antidote to Piconian skepticism. There is a dialectical topos of whole to part operative in the Horatian trope.[194] As in the contemporary Renaissance view of Horace's *Ars Poetica*, the audience was supposed to play a crucial role in deciding what was a good work of poetry, or a well-crafted *machina mundi*. Copernicus, like Landino, held that the audience is the final arbiter—but not just any audience. In the most famous line from the Preface—"Mathemata mathematicis scribuntur"—Copernicus emphasized that only a certain kind of community has the special competence to make judgments: those with mathematical skill and training. Most immediately, he meant those within the Church who were mathematically literate and who would not only understand and approve of his theory but would also accept the new standard for judging it; those without such disciplinary credentials would misunderstand and deplore it.

The preface, however, was at best reticent about the names of recent theoretical astronomer-astrologers. Neither Regiomontanus nor Peurbach, neither Girolamo Fracastoro nor Domenico Maria Novara was mentioned. And, most significant, it omitted Rheticus and the *Narratio Prima* altogether. The audience that Copernicus constructed in the preface divided the Church into two parts: those who were enlightened in mathematical subjects and those who were not. In the first group Copernicus included popes Leo X and Paul III, Cardinal Schönberg, Bishop Tiedemann Giese, and Paul of Middelburg. In the second, he placed untutored theologians—Copernicus called them "idle talkers"—who know nothing about mathematics and who he imagines will deride him by distorting scripture for their own purposes. The sole example of the latter was Lactantius. This contrast is quite interesting in light of our earlier discussion. Paul of Middelburg was clearly supposed to evoke orthodoxy with ecclesiastical associations to theoretical astronomy, legitimate astrological prognostication, and calendar reform; but the casual reference to Lactantius's mathematical incompetence makes sense only in the context of Rheticus's treatise on scripture, to which the preface makes not a single reference.[195]

Other elements of the Horatian topos resonated well with a variety of Copernicus's aims and in a wider semantic field.[196] First, Copernicus found what rhetoricians, artists, and poetic and visual theorists had long found in the *ut pictura poesis* formula: a discourse of bodily and literary coherence and an evocative aesthetic, connecting the poetic and the visual. The likely source for this ideal would have been available to Copernicus already in his student days at Padua. There, not only did Copernicus study medicine, but also it is very likely that he was involved with an active culture of artists. It has been suggested that Copernicus both knew Pomponio Gaurico and moved in the ambience of the Venetian artistic world, which included the revolutionary painter Giorgione and the Paduan artists Tullio Lombardo, Andrea Riccio, and Giulio Campagnola.[197] In 1504, just one year after Copernicus left Padua, Pomponio published his treatise *De Sculptura*. "A constant characteristic of the treatise," writes Robert Klein, "is the adaptation of rhetorical and poetical categories to the plastic arts."[198] The ideal property of the proportionally sculpted body, according to Pomponio, was its *symmetria:* "In every way our body is fitted together most precisely from measured parts, so that plainly one may regard it as nothing but a kind of perfect, harmonious instrument set in good order according to all the numbers."[199] It was but a short step from here to Copernicus's aesthetic in which "nothing can be moved from its place without causing confusion in the remaining parts and the universe as a whole."

Second, the Horatian image converged remarkably well with the political vocabularies of humanist curial reformers in the early sixteenth century as well as with familiar visual images of Reformation popular propaganda. At that historical moment, one of its connotations was reconciliation and reform. Within subtly overlapping arenas of language and image, one can see Copernicus treading a delicate path, recommending both that the Church pursue a reform of practical astronomy (alluding to the scandalous state of the calendar) and that it reconsider its association with theoretical teachings about the order of the heavens.

Copernicus represented the pope not as a granter of offices but as a protector. The pope "holds dominion over the Ecclesiastical Commonwealth" and answers not merely to an omnipotent deity but to a God of order—"The best and most orderly Artisan of all." As an advocate of new theoretical knowledge, Copernicus was striking forth into uncharted territory. He associated himself with the pope as protector of truth-seeking philosophers and the church's view of the heavens. The holy father's authority, moreover, came not merely from God but also from his specific human qualities: "Even in this remote corner of the earth where I live, you are considered the highest authority by virtue of the dignity of the office and love of the mathematical arts and all learning." Copernicus urged the pope to protect him against the hostility, uncertainty, and disagreement engendered by certain astronomers and philosophers: "By your authority and judgment, you can easily suppress calumnious attacks."[200] The language of the preface resonates effectively with Catholic reform literature of the same period. The writings of Raffaele Maffei (1451–1522), an influential curial figure, well exemplify this sort of political text. After reciting a litany of abuses that he hopes the pope will correct, Maffei uses the topos of the head and the body to urge a purging of the unnaturally greedy parts. "Your city, O father, must be cared for and renewed that it might not be ruled over by others who (as the Apostle says) would neglect their own home. Above all, [your city] must be restored to its primitive *libertas* and purged of the greed that goes contrary to your morals, since nature seeks that in which the members can be brought into conformity with the head, citizens with the prince, and, in a similar way, the flock with its shepherd."[201] The pope at the head of his flock is not corrupt; it is he who must expurgate those who are, and thereby protect Rome from abuse.[202]

Catholic church reformers used the image of the head to symbolize order and authority, but the many-headed monster also functioned as an image of moral disorder at the popular level. In German broadsheets of the 1520s, Lutherans employed the beast of the Apocalypse, with its seven unequal heads, as visual propaganda to attack papal indulgences, and Catholics later portrayed Luther as a many-headed, fanatical wild man.[203] Luther himself recognized the immense instructive power of visual signs, "above all for the sake of children and the simple folk, who are more easily moved by pictures and images to recall divine history than through mere words or doctrines."[204]

These "high" and "low" reformist points of reference help to situate Copernicus's moral imagery associating head and body, papal authority and celestial reform. Joined with his use of the Horatian aesthetic is a language of natural order and ethical conviction, underwriting a belief that astronomy's first principles are at once true and untainted.[205] By addressing Rome in this idiom of order and reform—resonant with both elite and popular connotations—he also evoked moral and political associations to which fellow clerics from his own local region of Varmia could respond. Indeed, Varmian religious politics was strongly humanist, irenic, and Erasmian in spirit, amid growing anti-Catholic sentiment and conversions to Luther's doctrines. Copernicus's closest Varmian friend, Tiedemann Giese, corresponded with Erasmus.[206] In the preface, Copernicus credited Giese with encouraging the publication of *De Revolutionibus*. In the *Encomium Prussiae*, Rheticus portrayed Giese as a radical reformer who pushed the cautious Copernicus not to conceal the theoretical principles from which he deduced his new system of planetary motions:

> The Most Reverend Tiedemann Giese, bishop of Chełmno . . . realized that it would be of no small importance to the glory of Christ if there existed an exact calendar of feasts in the Church as well as a sure theory and explanation of the motions [*certa motuum ratio, ac doctrina*]. . . . His Reverence pointed out that such a work would be an incomplete gift to the world [*munus Reipublicae futurum*], unless my teacher also set forth the sources [*causas*] of his tables and also included, in imitation of Ptolemy, the plan or method and the foundations and proofs [*quo consilio, quaue ratione, quibusque nixus fundamentis, ac demonstrationibus*] upon which he relied.[207]

Giese also wrote a treatise reconciling Copernicus's theory with the Bible (*Hyperaspisticon*, now lost), in which he borrowed the first word (*hyperaspistes*, or "shield bearer") from a polemic written by Erasmus against Luther.[208] And Giese shared the characteristic Erasmian view that gentle persuasion could achieve more than sharp criticism and satire. Differences of opinion could be resolved through love and toleration; Christian unity must come from within the church.[209] It was on this vulnerable but tolerant middle ground that the Lutheran Rheticus met the canons Giese and Copernicus.

The strategy of persuasion that Copernicus followed in his preface of 1543 undoubtedly reflects the outcome of earlier discussions with Giese and Rheticus, echoes of which are heard in the

Encomium Prussiae. Copernicus attempted to sidestep conservative elements in Rome while carefully omitting all references to the Lutherans Rheticus, Melanchthon, Gasser, and Schöner. His reformist rhetoric was neither stridently polemical nor satirical, but gently Horatian and Erasmian. It sought an end to controversy among astronomers, and, by implication, astrologers. It proposed an internal cadre of humanist *mathematici* to reform church teaching on the heavens by providing theoretical principles from which planetary order and calendrical accuracy could be restored. The entire enterprise was legitimated by papal authority and by appeal to a range of ancient pagan sources. The approach evokes Erasmus's broad reconciliation of Christian and pagan letters and also echoes the Beroaldo circle of the Bologna period in expounding a *philosophia Christi*, a life of lay piety modeled on the true life of Christ and the earliest sources of Christianity rather than on empty ceremonial practices and overly subtle Scholastic definitions.

The iconographical representation of Copernicus above the epitaph in his hometown parish church, Saint John of Toruń, provides evidence that his successors, at least, regarded his life in an Erasmian spirit, as a kind of *astronomia Christi*.[210] J. J. Vogel, the seventeenth-century artist, adapted his woodcut from an anonymous devotional painting of the astronomer (c. 1583). Melchior Pyrnesius (d. 1589), a younger fellow townsman and physician, commissioned the portrait and the epitaph. That Pyrnesius was carrying out Copernicus's wishes in the choice of wording for the epitaph cannot entirely be ruled out. The Latin, in sapphic meter, was one of thirty-four odes on Christ's suffering written in 1444 by Aeneas Sylvius Piccolomini, who later reigned as Pope Pius II (1458–64):

> Not grace the equal of Paul's do I ask,
> Nor Peter's pardon seek, but what
> To a thief you granted on the wood of the cross,
> This I do earnestly pray for.[211]

THE "PRINCIPAL CONSIDERATION"

The wider semantic field of the preface—its convergence with political and visual vocabularies of order and disorder—extended toward a broader audience that included the pope, and the hope of winning his public endorsement.[212] Regardless of its status as a dedicatory epistle, however, the preface went beyond standard epideictic gestures of praise and blame. It embodied seriously and accurately the logical structure of Copernicus's principal claim about the world. The essence of that claim was the same as the one stated in the *Narratio Prima* and the tenth chapter of book 1. In short, the assumption that the Earth is a planet may seem absurd, but the consequences of making that assumption make it more desirable than any other alternatives. And the consequence that Copernicus and Rheticus stressed most emphatically was the determinate ordering of the planets by their periods of revolution—about which there had been disagreement since the time of the ancients. The Copernican solution to that problem was presented by Rheticus as putting an end to the controversy initiated by Pico over the deeper grounds of natural divination.

The arrival in Frombork of the youthful, impassioned, and talented Rheticus seems to have energized the canon of Varmia and awakened his determination to move his ideas into print. The wealth of dialectical topoi that Rheticus wove into the *Narratio Prima* did not change the structure of Copernicus's logic; the gestures at necessity did not measurably strengthen the causal connection between the conclusion and the assumed premise. But the *Narratio* rhetorically amplified the more restrained presentation found in *De Revolutionibus* and left no doubt that astronomy aspired to true explanations, even if it could deliver only probable ones. By contrast, the position that astronomy's premises need not be true or even probable, incorporated by Osiander into his unauthorized "Ad Lectorem," represented the alternative that I believe Copernicus had already rejected more than thirty years earlier when he composed the *Commentariolus*.

Thus, baked into the prefatory structure of *De Revolutionibus* were the traces of Copernicus's early problem situation as well as the residual tension that defined the Copernican question: mutually contrary premises that logically entail the same conclusion. Osiander, to be clear, did not say explicitly that the Earth is a fictional point, but his position distinctly allowed and encouraged that view. Whether the Earth is a point or a real body revolving with the planets around a stationary Sun, the planets will be ordered such that the shorter the period of revolution, the closer it will be to the Sun, and the longer the period, the farther the planet's distance from the central body. Neither Copernicus nor Rheticus nor Osiander understood this situation as the problem of underdetermination as it was generalized some four centuries later by Duhem and Quine "for any finite body of evidence."[213] To paraphrase Peter Dear's well-conceived observation, we must learn to ascribe meanings in correct sixteenth-century ways to what appears to us now as self-evident.[214]