Introduction

Among the scientific authors of the ancient Greco-Roman world, none gives us such a strong impression of writing for posterity as Ptolemy. He lives in a time when learned and eloquent men seek and attain public adulation and private patronage, when the physician Galen performs dissections of pigs and sheep before the elite of Rome and when the sophist Alexander the "Clay Plato" dazzles the Athenian masses as much by his grooming and deportment as by his declamation. From this milieu Ptolemy is utterly remote. Outside of his books he is nothing; no contemporary mentions the man, and no later account of his life or person will preserve an authentic report. He addresses his books without flourish to a certain Syros, about whom we know nothing, and in them there is no personality, no reference to himself except as an observer, scholar, and theoretician, no allusion to his environment. His criticisms of other scientific practitioners are free of polemic. He habitually uses sesquipedalian verbs and writes vast, labyrinthine sentences; but his vocabulary and phrasing are repetitive, eschewing figurative language, and his tangled syntax results from the impulse to express the conditions and consequences of a thought all at once, and is worlds away from self-conscious rhetoric. Galen cannot refrain from bragging how profitable any book ascribed to himself is for the booksellers of Rome; one suspects that even in studious Alexandria Ptolemy's technical treatises are not exactly bestsellers. Nor is there anything meretricious about Ptolemy's efforts to give his science a public face: the inscription he erects at Canopus represents his cosmos as a bare list of highly precise numerical parameters, and his world map is a geometrical construction unembellished by crocodiles and pygmies.

And so Ptolemy's biography is practically complete when we have said that his full name was Klaudios Ptolemaios, and that he lived in or near Alexandria, made astronomical observations between the mid-120s and the early 140s of our era, and wrote books on scientific topics of which about a dozen have come down to us.[1] About half are astronomical, and of these, three are especially important. The *Mathematical Composition* (*Mathematikê Syntaxis*), better known since the Middle Ages as the *Almagest*, is a systematic treatise in thirteen books in which Ptolemy deduces the structure and quantitative parameters of geometrical models for the heavenly bodies from empirical evidence including specific dated observations. The *Almagest* also uses these models to derive tables for calculating the positions of the heavenly bodies on any given date, together with other phenomena such as eclipses and planetary first and last visibilities, but the tables also had a life of their own in slightly revised form as a separate publication that Ptolemy called the *Handy Tables* (*Prokheiroi Kanones*). Lastly, Ptolemy's *Planetary Hypotheses* (*Hypotheseis tôn Planômenôn*), a treatise in two books, gives a technical description, again slightly revised, of Ptolemy's celestial models, suggests how they are likely to be arranged relative to each other and what their absolute dimensions would be, and offers a physical interpretation of the geometrical models in terms of systems of revolving bodies composed of *aithêr*, the Aristotelian fifth element.

All Ptolemy's other writings have at least a glancing connection to his astronomy, but two are especially close. The *Tetrabiblos* (again a nickname—we do not know Ptolemy's own title, but a credible guess is *Apotelesmatika*, roughly "Astrological Influences") is a four-book treatise arguing for the viability of astrology as a physical science of the effects of celestial bodies on the terrestrial environment and on individuals, and on this basis Ptolemy undertakes a systematic reform of the general principles of astrological prediction. The *Geography* (*Geôgraphikê Hyphêgêsis*, "Guide to World-Cartography," also commonly known before modern times as the *Cosmography*) provides the principles and materials for the drawing of a map of the known parts of the world based on a critical analysis of astronomical measurements and other geographical reports.

Ptolemy crafted each of his major treatises to be self-standing, so that no reader would have to be familiar with other texts on the same topic to follow Ptolemy's argument on its own terms. Perhaps in part for that very reason, Ptolemy's tended to be the only works of their genres to survive into late antiquity and the medieval Byzantine and Arabic traditions. (The exception is astrology, which was handed down through many other texts in addition to the *Tetrabiblos*.) Each of Ptolemy's treatises has a distinct, sometimes complex path of subsequent reception and exploitation as a text of living scientific value, or of criticism that could lead to rejection. In the case of the *Almagest*, the presence of observation reports that, if trustworthy, might contribute to the measurement of the Earth's variable rate of rotation has kept that work from entirely subsiding into a condition of purely historical interest up to our own time.

From May 31 through June 2, 2007 the Division of the Humanities and Social Sciences at the California Institute of Technology, with generous support from the Francis Bacon Foundation, hosted a conference on uses and criticisms of Ptolemy's astronomical, geographical, and astrological works from antiquity through modern times, the focus being on the role of Ptolemy in current scientific practice and dispute. The present volume gathers most of the papers from that conference together with a new paper by the editor.

In the *Almagest* Ptolemy treats Hipparchus as his only legitimate predecessor in theoretical astronomy, making only brief and dismissively vague allusions to the astronomers of the intervening three centuries and his own time. Modern elucidation of traces of Greek astronomy in Indian sources (a field of evidence by no means exhausted, though tricky) have revealed that Ptolemy elided over a great deal of work in mathematical astronomy that had been done after Hipparchus, and the ongoing discovery of astronomical texts and tables among the papyri from Roman

Egypt is providing the historian with a still small but growing body of material relating to the immediate background against which Ptolemy's astronomy was first received. In the first paper in this volume, Anne Tihon gives us a first glimpse of a deeply interesting new papyrus manuscript containing passages from a work of unknown authorship written during the years when Ptolemy was still making the observations on which the *Almagest* was based. The topic is how to calculate the Sun's longitude in the zodiac using a set of tables that had surprising points of resemblance to Ptolemy's tables, and even more surprising differences. Among the lessons offered by this papyrus is that Ptolemy's was not the only version of solar theory descended from Hipparchus' researches, and that its correctness would not have been a straightforward matter to his better-informed contemporaries.

Alexander Jones (the editor) takes up a closely related topic, the problem of defining a frame of reference for celestial longitudes. The astrologers of Ptolemy's period did not distinguish between the tropical and the sidereal year, and used a frame of reference that was assumed to be tropical but in fact was approximately sidereal. Ptolemy's tables assume a tropical frame while attributing a precessional motion to the fixed stars. Papyri show that for two centuries after his time, Ptolemy's tables were commonly used only together with a correction that brought computed positions into a standardization of the prevalent frame of reference; this correction is identical to a formula associated by Theon of Alexandria with the doctrine of trepidation, or oscillating solstitial points. Jones attempts to account for the origin and motivation of this formula, and the cause of its later abandonment.

In the *Tetrabiblos* Ptolemy states his dissatisfaction with two methods of dividing the signs of the zodiac into Terms, that is, zones of a few degrees governed astrologically by one or another of the planets, and he recounts his discovery of a superior method in an old and damaged manuscript. Stephan Heilen offers a thorough critical treatment of the question whether Ptolemy's story is true or an audacious fabrication before exploring the reception of Ptolemy's system of Terms by astrologers from Ptolemy's day to the Seventeenth Century. This specimen of Ptolemy's reforming approach to astrology experienced a rather sad fate: transmitted in variously corrupted forms, it won little acceptance even from authors who gave lip service to Ptolemy's rationale for the system.

The *Geography* provides a set of resources for drawing maps of the world, including a catalogue of some eight thousand localities with their longitudes and latitudes. The earliest manuscript copies of the *Geography* that we have were produced more than a millennium after Ptolemy, and many of them have maps accompanying the text. The origin of these maps, and whether they descend through graphical copying from maps made by or for Ptolemy himself, have long been vigorously disputed. Relying on minute study of the manuscript maps and texts, Florian Mittenhuber makes a lucid and convincing case that the extant maps are the end of an unbroken chain of maps originating in antiquity, if not in Ptolemy's time, contrary to the belief of several scholars (including, hitherto, the editor) that they were recreated around A.D. 1300 purely on the basis of the transmitted text.

When astronomers or geographers attempted to repeat certain of Ptolemy's observations and measurements, different sorts of consequences could follow. In antiquity we know of no initiative to correct Ptolemy. Thus around A.D. 500 the Alexandrian Neoplatonist philosophers Heliodorus and Ammonius made a handful of observations of the positions of the Moon and planets, and on one occasion they noticed a discrepancy with Ptolemy's tables, but they apparently made nothing of it. On another occasion, Ammonius observed the position of Arcturus, finding it just where it was predicted from Ptolemy's star catalogue and precession rate; this observation did have the conservative effect of establishing the credibility of Ptolemy's precession theory in the eyes of Ammonius' pupil Simplicius. To help understand comparable but more complicated episodes from the Arabic astronomical tradition, Jamil Ragep draws a distinction between observations made to confirm a standing measurement, which are biased in favor of the *status quo*, and observations made to test. Ptolemy's estimate of the size of the Earth (from the *Geography*) was easy to revise once a test yielded a different figure, since there was no question of the Earth's changing size since Ptolemy's day. Tests conflicting with Ptolemy's values for the length of the tropical year and the obliquity of the ecliptic led to greater difficulties because of uncertainty about whether Ptolemy's measurements were inaccurate or the parameters had changed over time. Ragep argues that the sporadic occurrence of testing rather than confirming parameters in Arabic astronomy is a practice the historian should not take for granted but one demanding explanation.

The history of astrology in Europe during and after the Renaissance remains largely underexplored, and this is particularly true of the roles played by the *Tetrabiblos*. Darrel Rutkin presents two specimens of the uses to which Ptolemy could be put in polemic and education during the Fifteenth and Sixteenth Centuries. Pico della Mirandola professes a qualified respect for Ptolemy while twisting Ptolemy's discussion of the nature and validity of astrology into weapons in his attack on the discipline. A century later, Filippo Fantoni's lectures on the *Tetrabiblos* are the vehicle for a vigorous rebuttal of Pico, while Fantoni attempts to reconcile Ptolemy's theory that the heavenly bodies influence the sublunar world through the exertion of the elementary qualities hot, cold, moist, and dry with a more rigorous Aristotelianism.

N. M. Swerdlow takes up the threads of Ptolemy's solar and precessional theory, which have run through several of the preceding papers, with a precise account of how Tycho, Longomontanus, and Kepler tried to sort out the confusion of models and parameters that had resulted in part from the discrepancies between the *Almagest* and observations by Arabic and European astronomers. Tycho believed that the solar parameters had indeed changed since antiquity, but he deferred his solution of the long term behavior of the solar model to an ultimate comprehensive solar theory that he did not live to produce, meanwhile engaging in a dispute with Scaliger on the nature of precession that incidentally illuminates Scaliger's obstinate conviction that classical scholarship, not modern astronomy, held the key. Longomontanus' solar theory professed to be the fulfilment of Tycho's promise of a solution for all time; he proves to have been acutely critical of, though still dependent on, the observation reports in the *Almagest*, while also favoring certain parameters for their numerological perfection. Kepler, in turn, succeeded in isolating Ptolemy's reports of his own observations of equinoxes and solstices as the outliers (though the question of what caused Ptolemy's errors continued to trouble him), and thus he reintroduced a near-Ptolemaic simplicity into his solar theory by upholding the constancy of both the sidereal and tropical years, while including in his model a variable obliquity of the ecliptic.

Ptolemy's solar observations had not long been superannuated when his eclipse reports seemed to acquire a new utility from Halley's discovery of the secular acceleration of the Moon. John Steele narrates how Dunthorne, Mayer, and Lalande attempted to sift through the ancient eclipse records transmitted by Ptolemy and other sources. Dunthorne considered Ptolemy's reports to be insufficiently precise, while Mayer and Lalande suspected Ptolemy of tampering with them. But all three made some use of them, especially Dunthorne who singled out three reports that proved the phenomenon of secular acceleration and provided a basis for measuring it (though Mayer and Lalande preferred to use more recent but more precise observations for the latter purpose).

Notes

1. For detailed biography see Toomer (1975) and Jones (2008).