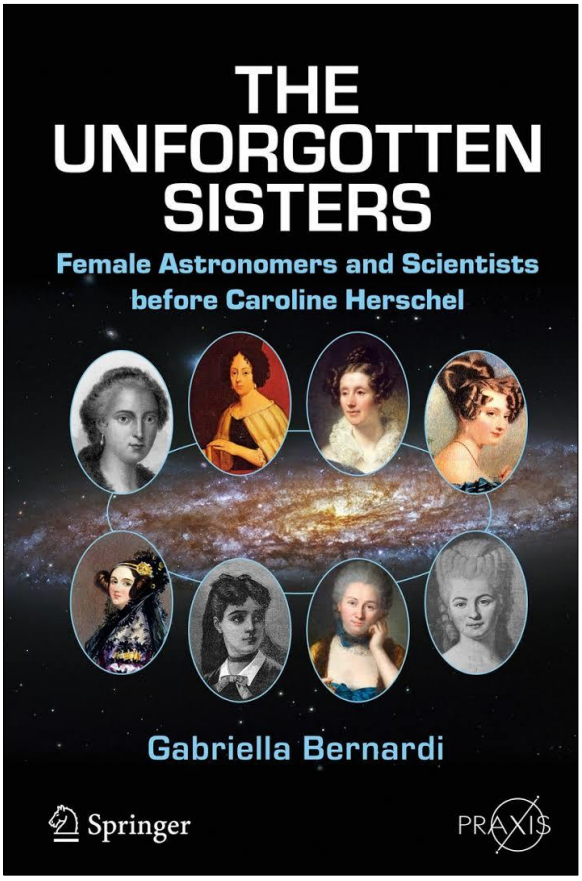
BOOK REVIEWS

***The Unforgotten Sisters: Female Astronomers and Scientists before Caroline Herschel*, by Gabriella Bernadi. (Springer International Publishing, 2016). Pp. 179. ISBN 978-3-319-26127-0 (eBook), ISBN 978-3-319-26125-6 (softcover), 155 × 234 mm, € 83.**

The Unforgotten Sisters traces the history of women engaged in mathematics and science, especially astronomy, from the twenty-third century BC to the nineteenth century AD. Gabriella Bernardi has degrees in physics and popular science and is a freelance journalist who specializes in astronomy. She does a masterful job in this book describing the hurdles women have historically faced as they pursued their interests in areas that were, for the most part, reserved for men. Numerous illustrations bring to life the women and the instruments they utilized in their work.



Although *The Unforgotten Sisters* contains actual letters of correspondence, the title Bernardi chose for this book comes from a fictional letter by Caroline Herschel that is written in poetic form by Siv Cedering. In it she describes some of her observations, calculations, and her work on the lenses and mirrors of the telescope that she and her brother, William Herschel, use to sweep the heavens. She then notes that:

> Sometimes when I am alone in the dark, and the universe reveals yet another secret, I say the names of my long lost sisters, forgotten in the books that record our science.

The book is divided into five major parts with a chapter devoted to each of the twenty-five women in chronological order. Timelines are given for each of the major parts, alerting the reader to well-known historical events and scientific discoveries that occurred during the same time period. Though not a distinctive topic, Bernardi discusses in unusual detail the historical context in which each of these women worked, their main area of expertise and any papers published, as well as records and citations of their observations and calculations. She livens up what could have become a dry presentation of historical facts with curious facts about these women, their families, and their individual circumstances.

Bernardi offers clear-cut examples of women in astronomy whose work has been unrecognized or almost forgotten over time. For instance, Maddalena and Teresa Manfredi, with the possible collaboration of another sister, Agnese, aided their brother Eustachio in the astronomical observations and mathematical calculations required for the 1715 publication of the *Ephemerides of Celestial Motion*. However, they never signed or took credit for any of their work. It is only in the preserved original manuscript—not the printed edition—that their brother states this work, including the required calculations, was completed with the help of his sisters.

Most of the women Bernardi includes in her book came from privileged backgrounds, with access to an education in science and mathematics historically denied to women. One such example, Sonduk, the first female monarch of Korea (from AD 634–637), developed a strong interest in astronomy at a young age. After she succeeded her father, her continued interest and means led to the construction of the oldest surviving astronomical Observatory in the Far East.

Quite a few of these early female astronomers studied privately with their fathers, brothers or husbands. However, if they went on to work ‘professionally’ with these men, their research was often incorporated with and credited to their male mentors. For instance, Maria Margarethe Winkelmann-Kirch was the first woman to officially discover a comet. As was the custom of the time, though, all her independently made discoveries were incorporated under the authorship of her husband, so her discovery of a comet in 1702 originally was credited to him.

Disappointingly, the early chapters of this book provide few specific details such as those

given above. However, this is not due to a lack of effort on the author's part, it is simply due to the fact that many of the ancient Babylonian, Egyptian and Greek manuscripts were destroyed or lost over time. Bernardi fills in, though, with interesting historical notes regarding ancient customs and astronomical knowledge. This book would be useful as a reference, but is confusing in places due to an incorrect usage of personal pronouns. A more careful edit would have made it easier to read.

The Unforgotten Sisters will be appreciated by anyone interested in the history of astronomy or women in science and mathematics. It will be of particular benefit to girls wishing to pursue a degree or career in astronomy as it highlights achievements made by women through sheer determination. All readers will come away with a high regard and an appreciation for each of these women and the individual challenges they faced while pursuing a greater understanding of all things astronomical.

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***The Glass Universe: How the Ladies of the Harvard Observatory Took the Measure of the Stars*, by Dava Sobel. (New York, Viking, 2016). Pp. xii + 324. ISBN 978067001952 (hardback), 160 × 235 mm, US$30.**

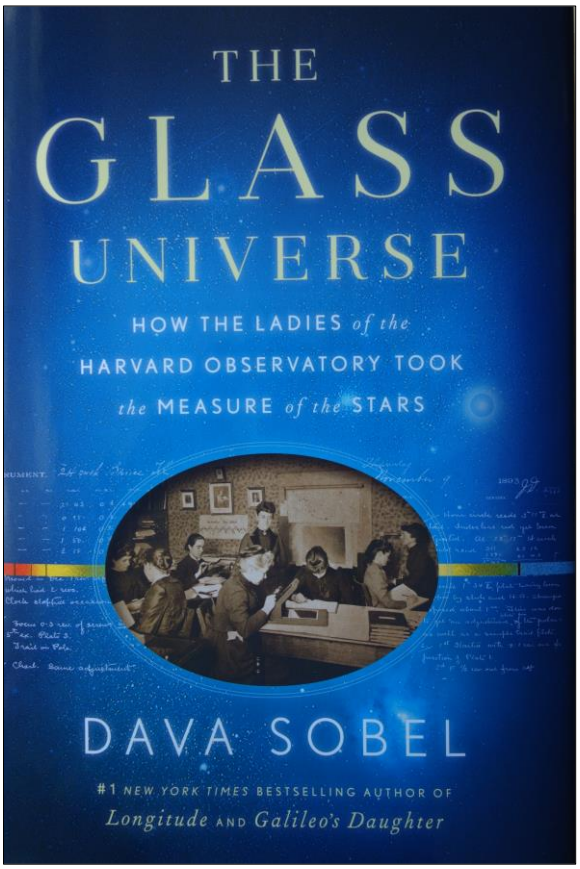
The popular science author Dava Sobel has produced some excellent books, and one that is questionable. My favourite one is *Letters to Father* from 2001, consisting of letters written to Galileo by his daughter. Her 1995 book *Longitude* unfairly maligned Great Britain's Astronomer Royal, Nevil Maskelyne, as a villainous character. She is back on solid ground with this book about the women who by virtue of their intelligence, dedication and largesse played a pivotal role in the development of astronomy at Harvard Observatory in the late nineteenth and early twentieth centuries.

Elements of the book were especially interesting to me as I knew several of the people Sobel writes about. These include Bart Bok, and Helen Sawyer Hogg, who officially opened my own observatory dedicated to asteroid photometry. The timeline at the conclusion of the book includes Dr Hogg's marriage in 1930 and her award of the Annie Jump Cannon Prize in 1950. However, the timeline is inconsistent as it notes the passing of some, but not all, women who feature in this book. Among these missing entries are Drs Hogg and Priscilla Fairfield, in 1993 and 1975 respectively. In 1921, Fairfield was one of the first women to receive a Ph.D. in astronomy. She began working at Harvard in 1923,

> … comparing the spectra and proper motions of giant and dwarf stars belonging to Draper class M, in order to more clearly define the line distinctions between them. (page 217).

Sobel tells us that Fairfield was able to pay her student assistants 30 cents an hour to help, thanks to a $500 grant from the National Academy of Sciences.

In 1928 Fairfield attended "… the largest and most global gathering of astronomers ever united." (page 223). This was in Leiden, where 243 delegates, including 14 from post-world war Germany, met to discuss all aspects of astronomy. Sobel informs us "The moment Miss Fairfield stepped off the train at the Leiden station, she attracted the attention …" of a certain Dutch astronomy student. Miss Fairfield



> … tried to fend off the amorous advances of her new suitor, who, at twenty-two, was a good ten years her junior. Bart Bok persisted, however, and at length overcame her misgivings. (page 224).

Miss Fairfield thus became Mrs Bok. This extract is given to show one of this book's great strengths—the interweaving of both professional and personal information, which provides texture to the great story Sobel offers us.

While she concentrates on the ladies of Harvard Observatory, Sobel necessarily must also delve into the careers of the men who ultimately ran the place. Among these is Harlow Shapley,

whose views of the cosmos were repeatedly shown to be at odds with reality. Sobel quotes from his letters to give us a real-time sense of what he was thinking on the great issues of the day. In July 1918, while World War I was still raging, Shapley wrote to Edward Pickering

> I believe the most important photometric work that can be done on Cepheid variables at the present time is a study of the Harvard plates of the Magellanic clouds. (page 170).

This is a perfect example of the warning, 'be careful what you ask for'. Shapley believed our Galaxy was the entire Universe, but a study of Cepheid variable stars, particularly in the so-called 'Andromeda Nebula', proved that our Galaxy is one of many. It was Edwin Hubble in 1924 who found a Cepheid in the Nebula, showing it is at least a million light years away. Instead of just mentioning such a discovery in dispassionate scientific terms, Sobel puts us in the moment with this dramatic sentence:

> After Shapley read Hubble's news and looked at the light curve, he held out the pages to Miss Payne, saying, 'Here is the letter that has destroyed my universe.' (page 204).

I have just mentioned the Harvard plates, which, along with the ladies, are the co-stars of this book. Thanks to the large and continuing grants of money from Anna Palmer Draper, Harvard was able to establish a suite of telescopes in various countries to advance astronomical research. The centrepiece of this work was photographic, and resulted in hundreds of thousands of plates that contained the treasures of the Universe. It was this treasure trove that was mined by dozens of young women whose lives and careers are sensitively traced by Sobel. She looks at those who achieved immortal fame, such as Annie Jump Cannon, Antonia Maury and Henrietta Leavitt, along with many others who are nearly forgotten. Some of these dedicated women literally worked themselves to death in the cause of science, and this book serves as a fine testament to their efforts.

The index has some issues. For example, the asteroid Eros is listed with several page entries, but its appearance on pages 155 and 160 are missing. The 8-inch Bache telescope at Harvard College Observatory is likewise given several page references, but its mention on page 72 is missing from the index. Fairfield's entry is given twice, once under Fairfield, Priscilla and again under Bok, Priscilla. These are just three examples.

Despite my minor quibbles, Sobel has produced a readable and engaging account of how modern astrophysics developed, and the crucial role of women in that grand endeavour.

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***Discovery of the First Asteroid, Ceres*, by Clifford Cunningham (Springer International Publishing, 2016). Pp. xiii + 333. ISBN 978-3-319-21776-5 (hardback), 157 × 240 mm, €129.99.**
***Early Investigations of Ceres and the Discovery of Pallas*, by Clifford Cunningham (Springer International Publishing, 2017). Pp. xix + 412. ISBN 978-3-319-28813-0 (hardback), 157 × 240 mm, €149.99.**

This five volume series covers historical studies in asteroid research and, judging by the first two volumes reviewed here, this project will be an all-encompassing compilation and definitive study of this topic. Building upon and substantially revising the author's earlier work in many areas, Cunningham combines a historian's love of detail with a sense of the wider impacts of events to retell one of the great stories in the development of our understanding of our Solar System through the application of mathematical tools that has focused the power of human intellect to understand the nature of the Universe.

These two books follow a common structure: the introductory chapters cover the main topics and draw upon correspondence between the major figures to advance the narrative. Subsequent chapters reproduce books, correspondence and letters to provide an original source perspective on the events of the time. This is one of the books' major strengths, namely the publication in English of original sources regarding historical developments. Cunningham illustrates the broader impact of events through examples of verse and art. The illustrations enrich the story and include images of people covered in the narrative, together with cover pages of major publications.

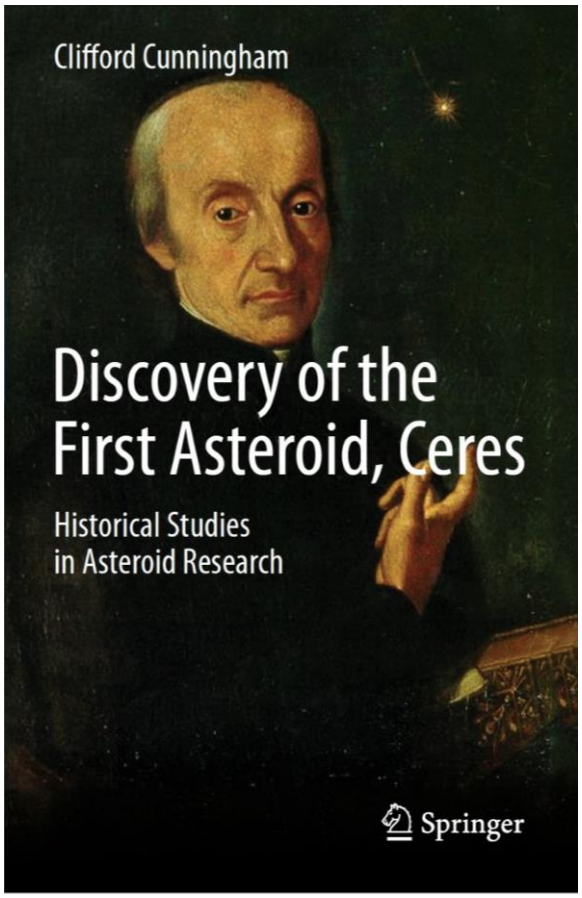
Another strength of these volumes is the connection that the author makes between the tight world of professional astronomy and the broader aspects of human society. The impact of new discoveries on literature and art is presented by numerous excerpts from noted writers and by many illustrations from publications of the times communicating discoveries to the broader public.

Volume One, Discovery of the First Asteroid, Ceres

After tracing the idea that there just might be another planet between Mars and Jupiter back to its origin with Kepler, Cunningham describes its development as a mathematical relationship relating the size of planetary orbits in the introductory chapter. Herschel's discovery in 1781

cemented the validity of this theory when Uranus fitted nicely into the framework. Plausibly there was an undiscovered planet there so European astronomers set out to find it. Chapter 2 relates the intriguing story of how Ceres was actually discovered, including errors made along the way. The following chapter covers one of the great stories in astronomy: the recovery of Ceres due to the mathematical genius of Gauss when observational searches proved fruitless. This chapter is enriched with an essay by Brian Marsden recounting this recovery. Chapters 4 and 6 describe the ensuing controversy over naming of this new world and how the public first learned about Ceres.

Chapter 5 describes the initial efforts to determine the physical properties of Ceres and the realization that it did not fit any of the models for what a planet or a comet should be.



Books by Piazzi, Bode and Schroeter, and correspondence and letters between the leading figures in this story are included in Chapters 7–14. Four appendices flesh out details of the instrument that Piazzi used to discover Ceres, a chronology of the events of 1801, development of the orbital elements of Ceres and a recounting of the various star charts that played a crucial role in the discovery.

The story of their success is interwoven with the personalities and politics, along with contextual international events. What sets this volume apart from previous works is the comprehensive detail that Cunningham has assembled. Numerous interesting details bring human elements to the story such as the account of Cacciatore on the events surrounding the discovery of Ceres and the subsequent efforts of Piazzi to minimize the importance of his role. Cacciatore's alternative perspective points out the all-too-human characteristics of who history records as great discoverers. Piazzi's eagerness to receive full credit is further illustrated by the apparent efforts that he took to make it difficult for others to find Ceres in the sky. The collecting of original communications, publications and notes, all presented in English, provides a valuable resource for any student of asteroid science and the scientific historian.

There are only minor issues with this volume. The section in Chapter 2, page 38, titled "When Was Ceres Seen for the First Time", leaves the reader puzzled as to what the answer is. This rather vague recounting adds little to the question. Also, the caption to Figure 2.3 on page 29 states that "Figure 2.3 show the seven stars from Piazzi's …" However this figure actually depicts the front and back of a medal.

Finally, an update. The table on page 89 now needs to be modified to reflect the DAWN determination of the size of Ceres (a mean diameter of 588 miles), rather than using Millis' 1987 value.

Volume 2. Early Investigations of Ceres and the Discovery of Pallas

The first five chapters of this volume cover a wide range of topics, from the general state of mathematics in European countries to the origin of the word 'asteroid' to describe Ceres and the other bodies found in this region of the Solar System. Chapter One explores the role of mathematics in understanding the world and then explores why there were fundamental difference between the methods of celestial mechanics as practiced in France and Germany. This difference was crucial as the French failed to succesfully predict the location of Ceres, while Gauss, with the German influence (Ramism), succeeded. Cunningham inserts his own perspective:

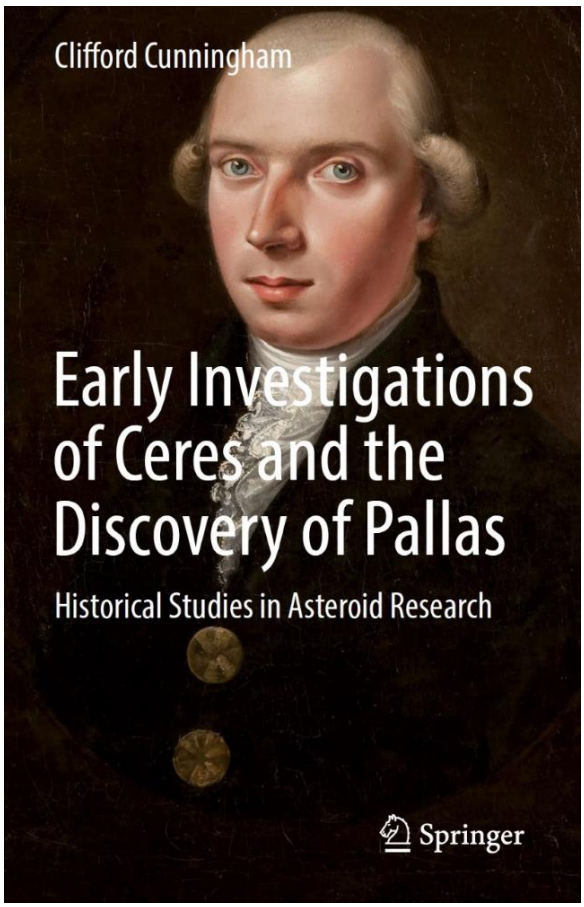
> I contend that one of these new aspects arose in the study of celestial mechanics around 1800. My analysis does not suggest that Ramism was deliberately or consciously employed in this effort that found its greatest expression in the recovery of Ceres. (page 12).

One need only look ahead 45 years to the discovery of Neptune to see how the fortunes of French celestial mechanicians had improved.

Chapter 2 compares the state of science and mathematics in France with that of Germany,

with a bit of England and English satire thrown in, while Chapter 3 explores professional rivalries among the leading German, French and English astronomers of that time. The following chapter recounts the origin of the term 'asteroid' to describe these newly discovered objects that clearly did not belong to the same class of objects as the planets. The section on "What is a Planet? A View from the Eighteenth Century" raises a question that invokes deeply held opinions even today and will likely undergo further revisions as our knowledge of exoplanets expands.

In Chapter 5 we arrive at The Discovery of Pallas by Olbers, on 28 March 1802. Rather than describing the discovery events in detail in his own words, Cunningham tells the story as told



in the words of Olbers himself from a letter. Few words are spent on the actual discovery before the narrative moves on to a discussion of the nature of Pallas. This is followed by a discussion of the 'exploded planet' hypothesis of Olbers, presented on 15 May 1802. The remainder of this chapter deals with Bode's attempt to preserve his law and an extensive section on how the public learned of the discovery of Pallas. More details of the circumstances of the discovery of Pallas would be welcome here. While Olbers was searching for another planet, in the broad sense, he was following Ceres on 28 March—so was it sheer luck that Pallas was close by, thus enabling its discovery? Did Olbers have a broader strategy in his search for a new world? Why was Olbers looking for another planet in the first place, since Ceres had filled the gap between Mars and Jupiter? Appendix B gives the positions of Ceres and Pallas in 1801–1802, but the ephemeris for Pallas (Figure A2) covers only dates in April and May, not 28 March. Giving the location of both bodies on the discovery date would enable the reader to judge the degree to which chance was crucial in the discovery of Pallas.

Chapters 6–10 reproduce original logbooks, letters, books and scientific papers by various participants in this story and contain interesting insights into the origin of various ideas. For example, Ende suggested to Olbers that Pallas might have resulted from a cosmic catastrophe (the 'exploded planet hypothesis'), but is never given credit for this, as Cunningham notes. Another example is in the letter from Gauss to Olbers where Gauss introduces the idea that these bodies might collide:

> Both paths would come frightfully close together at a place not far from the area where the two stars are. Our descendants could perhaps some day be spectators of the most terrible phenomenon: the collision of the two celestial bodies!

Today studies of asteroid collisional evolution are a fundamental component of understanding the origin and evolution of this population.

These two books are definitive works on the discoveries of Ceres and Pallas and provide deep insights into the broader context and impact of these events. They are intended primarily for the historian of planetary science and those interested in the impact of new discoveries in science on human culture. While the vast amount of material assembled in these volumes may be intimidating for the casual reader, they do provide a rich resource for both serious researchers and students of asteroidal history. Cunningham has done a great service to this field by producing these works.

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***Roman Portable Sundials: The Empire in Your Hand*, by Richard J.A. Talbert. (Oxford, Oxford University Press, 2017). Pp. xxi + 236. ISBN 9780190273484 (hardback), 170 × 240 mm, US $55.**

Richard Talbert, the William Rand Kenan Professor of History at the University of North Carolina, is the world's leading authority on ancient geography. He has now brought this expertise to bear on portable sundials that embody

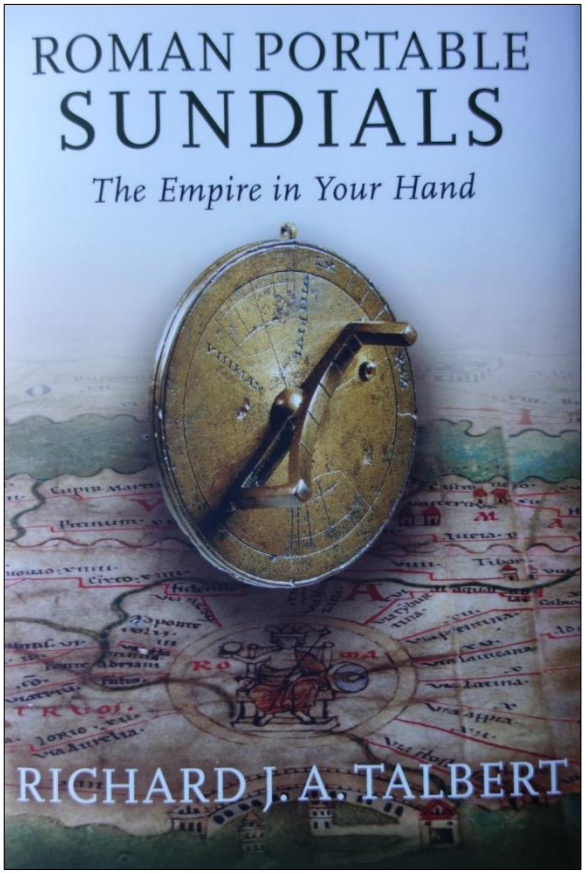
spatial data.

During the annual conference of the Classical Association of Canada in May 2017, at which we both presented research papers, I was able to interview Professor Talbert about his book, and this is what he told me:

> I am not interested in these instruments *as such* … For the ancient sundials, all the conversation has always been about how these instruments are designed and produced and how accurately they can tell the time.

This book is a noted and welcome departure from those purely technical studies, and gives us a novel insight into the role of time in everyday Roman life.

Talbert looks not just at portable sundials, but at a subset of them that contain geographical information. "On the reverse there is a listing of



either province, island or city names each with its own latitude figure …" Talbert explained. He then elaborated:

> What interests me as a historian, is that when you look at these lists, almost all of them are pretty clearly individual creations. They can fit as many as 36 names on these sundials. These belonged to people who are cosmopolitan: they have a vision of the whole Greek and Roman world. They then pick some that they want to have on the back of the sundial as a kind of speed dial list.

This way of regarding these portable sundials opens up a whole new field of investigation into ancient Roman people and society. Talbert told me he terms it 'mental mapping', a way of getting "… a glimpse of what these peoples' world view was."

In the first, rather brief, chapter, Talbert notes only one mention of portable sundials in ancient literature. It comes from Vitruvius (late first century BCE) who tantalising says sundials were made "… for taking on a journey and hanging up." (page 10). As the author makes clear, our certain knowledge about portable sundials derives entirely from the extant examples. Who made them, where they were made, who owned them, and many other basic questions, cannot yet be answered.

Chapter 2, which comprises 90 pages, is a case-by-case review of each portable sundial that is engraved with geographic information. In all there are 16, although Talbert suggests that others may be languishing in private hands or museum collections. Of the 16, several have been lost, and we are left only with a diagram. Most consist of circular disks, but one in the Archaeological Museum at Philippi in Greece comprises three nested rings. "It's design is remarkable …" the author writes. "It matches that of the 'astronomical ring dials' known from the Renaissance onward and not previously thought to have had any forerunners." (page 76). It likely dates from between 250 and 350 CE.

The center ring of this unique example comprises two half-rings, which contain four locations: Alexandria, Rhodes, Rome, and Vienne (located in the southeast portion of France). The inner ring (marked with 12 divisions for the hours) includes a slit "… pierced in the center by a small hole. Rays of the sun passing through this hole mark the time." (page 81).

The remaining three chapters look at the existing evidence for clues about the use of these small sundials. Some derive their geographical information from Ptolemy's *Geography* (ca. 150CE). In this volume, Ptolemy gives the position of 6,000 settlements and features across the known world. Talbert notes "His inspiration came from celestial mapping …" (page 119) in his *Almagest*, which is known in astronomy as the most influential book of all time as it shaped our understanding of the cosmos to the time of Copernicus and beyond.

Talbert's book concludes with an intriguing appendix about a marble fragment found in Budapest in 1990. Talbert is the first to suggest that this is a sundial-makers' manual that was "… discarded sometime during the second or third centuries CE." (page 218). This highlights the likelihood that future archaeological discoveries will

reduce the level of conjecture about portable sundials that Talbert was obliged to take.

This is a fascinating and eminently scholarly book that is the first to focus attention on this important aspect of Roman timekeeping, and Oxford University Press is to be commended for publishing the many photographs with the clarity required to see the fine details commented upon by the author.

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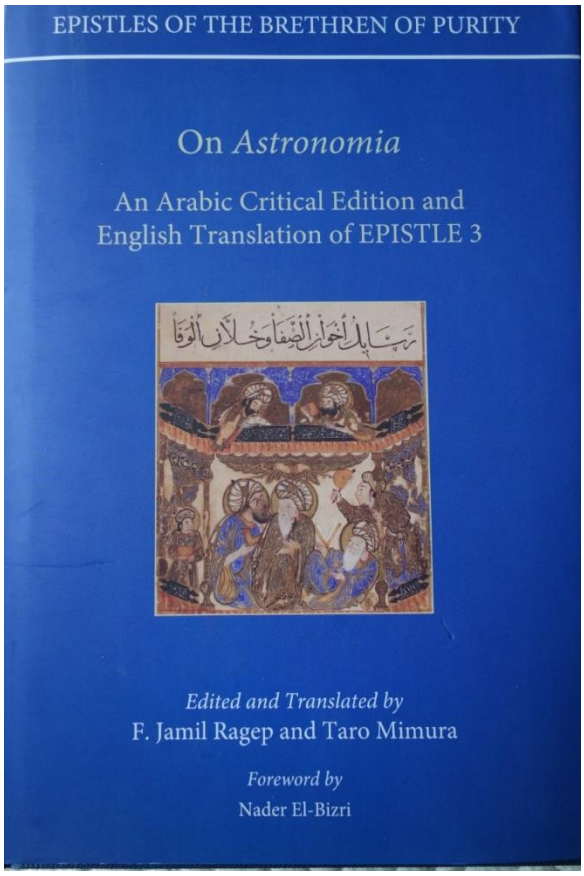
***On* Astronomia*: An Arabic Critical Edition and English Translation of EPISTLE 3*, edited and translated by F. Jamil Ragep and Taro Mimura, foreword by Nader El-Bizri, Epistles of the Brethren of Purity (Oxford, Oxford University Press in association with The Institute of Ismaili Studies, 2015), pp. 352. ISBN 9780198747376, 156 × 234 mm, £50.**

The Brethren of Purity were a secretive society in tenth-century Iraq. They gained prominence in the history of Islamic science and philosophy through fifty-two Epistles that were widely read and copied. Written by anonymous members of the fraternity, the Epistles covered various branches of the natural sciences, philosophy, and theology. The brethren were perhaps not among the greatest scientific authorities of their age. However, they were still influential in bringing together, and popularizing, diverse areas of knowledge. Due to their prominence, modern scholars started editing the Epistles and translating them into European languages as early as the nineteenth century. However, these editions and translations were incomplete and often uncritical. The Institute of Ismaili Studies in London built on these efforts to produce a more definitive edition of the Arabic text as well as an English translation. After an introductory book published in 2008, Epistle 3, *On* Astronomia, is the eighth volume in the Institute's series.

The word *Astronomia* in the epistle's Arabic title (*al-asṭrunūmiyā*) is the transliteration of a Greek word that encompasses both astrology and astronomy in the modern sense. The Epistle covers both areas of knowledge, but with a focus on astrology. It is primarily didactic and scientifically neither 'creative' nor 'insightful', as the editors write in their introduction (page 4). The astronomical and astrological contents can be found in earlier works by Ptolemy, Abū Maʿshar, and Farghānī. The most interesting aspect of the work is perhaps its adaptation and combination of Arabic and Greek, Islamic, Christian, and pagan thought. The Epistle quotes the Qur'an as well as the gospels of Matthew, Mark and Luke. Muhammad is part of the Epistle, as are various Biblical figures, including Abraham, Jesus, John the Baptist, Moses, Noah, and Zachariah. Among Greek philosophers and scientists, Aristotle, Diogenes, Ptolemy, Pythagoras, and the Pythagoreans appear. The Brethren of Purity engaged in such syncretism in order to demonstrate the harmony of the Universe and to offer the reader moral and spiritual guidance. The Epistle's subtitle describes it as a text "… for improving the soul and rectifying character." (page 21). Understanding God's perfect design of the cosmos would help people adopt proper conduct and reach happiness and salvation, the fraternity argued.

The Epistle contains around thirty-two main chapters plus thirteen additional ones at the end of two of the manuscripts. The astronomical content includes the yearly motion of the Sun, the seasons, and solar and lunar eclipses. The



Brethren of Purity also described the motions of Saturn, Jupiter, Mars, Venus and Mercury through the orbs, which are, "… spherical, transparent, and hollowed-out bodies." (page 26). Astrological chapters characterize and divide the zodiacal signs. Furthermore, the Epistle relates these signs to the Sun, Moon and planets through accounts of houses and detriments, decans and their lords. Other chapters are devoted to divine providence and salvation as well as numerology.

The editors have produced the most comprehensive and useful edition and translation of the

brethren's Epistle 3 to date. F. Jamil Ragep and Taro Mimura used seven manuscripts from Istanbul and Tehran that had been completed between the twelfth and the fifteenth centuries. Footnotes and appendices with additional chapters preserve the variations between the different manuscripts. Another appendix consists of a concordance of manuscripts and a previous edition published in Beirut. The English translation is accurate and mostly literal, giving a good feel of the Arabic. However, as a result, perhaps only specialists in ancient and medieval history will find the text easy to read and particularly enjoyable. Even the editors' introduction is itself very technical. Nevertheless, Ragep and Mimura have tried to help modern readers as much as possible. Arabic and English indices list subjects, terms and quotations from scripture. Moreover, a glossary includes Arabic concepts and their English equivalents. Finally, a four-page bibliography includes valuable suggestions for further reading.

Although the epistles of the Brethren of Purity were popular in pre-modern times, the appeal of a critical edition and largely literal translation, like Ragep and Mimura's, might be limited to scholars. Nevertheless, among academics, *On* Astronomia is of interest not just to historians of Arabic and Islamic science. Because of the Brethren's inclusion of Hellenistic philosophy and Biblical material, the epistle is a valuable document for the wider study of late antique and medieval intellectual history and for understanding the relationship between science, religion and philosophy. In his foreword, Nader El-Bizri, the General Editor of the series, placed the Epistles of the Brethren of Purity "… amongst the distinguished Arabic classics and the high literature of Islamic civilization." (page xx). However, *On* Astronomia can be seen as part of Hellenistic and wider Abrahamic traditions as well as an Islamic one.

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