Ptolemy's Life and Works (Akademie Aktuell)
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Ptolemy is not an inviting figure for the kind of biography that thrives on personal anecdotes and social context—and this is surprising, since he lived in a place and time (the Roman Empire under the Antonine emperors) when intellectuals were expected to be extroverts, competing for the adulation of the educated elite through public performances as well as writings. His younger contemporary, the physician Galen, was supremely at home in this world, ever rising in social status and connections while somehow finding the time to write books that constitute about a tenth of the surviving corpus of Greek literature up to his time and that are filled with allusions to his life and opinions. Ptolemy, by contrast, seems to have kept a minimal public profile, and the only biographical facts that he allowed into his writings are the dates of some of his astronomical observations, ranging from AD 127 through 141, and the location where he observed, Alexandria. Only two contemporaries are named in his writings: a certain Syros to whom he dedicated his astronomical and astrological works, and a certain Theon who supplied him with reports of astronomical observations.

Though less vibrant as a center of scientific research and teaching than it had been in the Hellenistic period, 2nd century Alexandria was still, as Galen tells us, the place to go *par excellence* for astronomy. The teaching of such technical disciplines beyond elementary generalities was likely carried out one-on-one or with small groups of students, and scientists had to rely on their own resources for the research tools, that is, their instruments and books; the importance of the Library of Alexandria for Roman times has been greatly exaggerated. Ptolemy's full name, Klaudios Ptolemaios, indicates that his grandfather or great-grandfather had probably acquired Roman citizenship during the reign of Claudius (AD 41-54), and the family was sufficiently affluent for him to devote his life to intellectual pursuits. In several of his writings he shows himself to be conversant in philosophy, with affinities to Middle Platonism and Aristotle. He was also widely read in the mathematical sciences but betrayed little interest in or familiarity with medicine or biology.

Astronomy was at the heart of Ptolemy's scientific interests, and the great project of his career was to construct a logically compelling deductive exposition of the mathematical structures underlying the visible motions and phenomena of the Sun, Moon, planets, and stars. Ptolemy completed this massive treatise in 13 "books" (i.e. papyrus rolls), the *Mathematical Composition* (familiar to us as the *Almagest*), after AD 146, at least twenty years after he began his astronomical observations. Its basic framework, laid out with empirical justifications in the opening chapters, is a modification of Aristotle's cosmology: at the center of the Cosmos, a stationary spherical Earth composed of unstable matter whose irregular properties and processes of change are not susceptible of exact scientific understanding; and enclosing it, a spherical shell of eternal celestial matter, whose constituent parts, including the visible heavenly bodies, perform combinations of perfectly regular circular motions for all time. The task Ptolemy set himself in the *Almagest* was to use a combination of generalized empirical facts, particular observations performed on specific dates, and mathematical analysis to demonstrate which specific combinations of circular motions were involved for each heavenly body, with precisely determined periodicities and dimensions, and to show that these *hypotheses* (best translated as "models") allow one to predict the apparent positions and phenomena in agreement with observed reality. The scientific reasoning of the *Almagest* is so tightly interconnected that it can be considered as the largest and most complex coherent deduction in all early science. Although Ptolemy intended it as a didactic work (in the highest sense) and not a history of its subject, it was and remains the principal source of information for later times on the methods by which Greek astronomers applied observations to develop quantitative models. Its testimony is particularly important for our knowledge of the lost works of Ptolemy's 2nd century BC predecessor Hipparchus on the theories of the Sun and Moon.

At various points in the *Almagest*, Ptolemy presents numerical tables that represent various aspects of Ptolemy's astronomical modelling in a form that enables easy calculation of positions and phenomena of the Sun, Moon, and planets on arbitrary dates. Realizing that the widespread practice of astrology created a market for these tables independent of the theoretical discussions, Ptolemy published a revised version of them, the *Handy Tables*, accompanied only by a set of instructions for their use. In later antiquity there were probably many more copies of the *Handy Tables* in circulation than of the *Almagest*; this is the only one of Ptolemy's works that has been found so far among the hundreds of thousands of fragmentary Greek papyrus manuscripts recovered from Roman Egypt.

In other works, Ptolemy took up topics that had been only tentatively addressed in the *Almagest*. One was an analysis of the conditions determining whether a star is visible close to the horizon soon after sunset or before sunrise; this was a prerequisite for predicting the dates in the year when stars are first or last visible in the morning or evening, events which the Greeks traditionally connected with changes in the weather. Ptolemy wrote both a theoretical treatment of this problem, which has not survived, and a calendar (the *Phaseis*) combining his calculated dates of first and last visibility with reputed dates of weather changes ascribed to various authorities of the past.

The *Planetary Hypotheses* is a more important work from late in Ptolemy's career. Only the first quarter of it survives in Greek, but the complete text, or nearly, is extant in medieval Arabic and Hebrew versions. Here Ptolemy presents technical specifications of his models for the motions of the heavenly bodies, following the *Almagest* but with certain modifications and stripped of the deductive arguments. Moreover, going beyond the *Almagest*, he offers tentative accounts of the absolute dimensions of the various components of his astronomical system, the causes of motion of these components (he believes that celestial souls impart motion to the etherial bodies, not operating through mechanical connections), and the breakdown of the system into distinct three-dimensional components that revolve with their surfaces gliding friction-free against each other.

Two further comparatively short works concern techniques of representing the three-dimensional geometry of the celestial sphere in two dimensions. The *Analemma*, which addresses the mathematical treatment of sundials and related astronomical problems, survives only in fragments in a 7th century AD palimpsest manuscript and in a Latin translation, apparently also not complete, made from a lost Greek manuscript by William of Moerbeke. The *Planispherium*, lost in Greek but extant in Arabic translation and in Hermann of Carinthia's Latin version from the Arabic, discusses the construction of diagrams of the celestial sphere in stereographic projection, a technique that translates any circle on the surface of the sphere into a circle on the plane of projection. Stereographic projection was the principle underlying the construction of plane astrolabes as well as the dial plates of some sophisticated water-driven clocks, though Ptolemy does not directly refer to such applications.

Ptolemy drew a categorical distinction between astronomy and astrology, which he described as a predictive science dealing with the physical effects imparted by the heavenly bodies on the material world below, including both individuals and the broader environment. There is no astrology in the *Almagest*, except for glancing allusions to techniques of weather prediction; but Ptolemy composed a major treatise on astrology, completing it probably not long after the *Almagest*. We do not know Ptolemy's title for this work, but it has come to be called the *Tetrabiblos* or *Quadripartitum* from the fact that it is in four books. Ptolemy takes an intermediate position between strictly deterministic astrologers who held that exact predictions of human lives could be predicted reliably from the instantaneous configuration of the heavenly bodies at a critical instant and sceptics who rejected both the utility and the validity of astrological prediction. For Ptolemy astrology is necessarily inexact because it concerns cause-and-effect relations operating upon mundane matter, but its fundamental validity and utility are established by the existence of universally accepted, manifest connections between astronomical and terrestrial conditions. The *Tetrabiblos* aims to present the precepts of astrology, at the most general level as well as in the particular forms relating to geographical regions and to individuals, in a form consistent with correct astronomical theory and with the principles of physical change in matter.

Cartography was another subject that drew on astronomy to define the framework of latitude and longitude that fixed localities on the globe. Ptolemy's *Geography*, in eight books, boiled down an immense mass of geographical data into a catalogue of some 8000 localities with their latitudes and longitudes, on the basis of which one was enabled to draw maps of the entire known world or particular regions. The map projections that Ptolemy devised sought to minimize disproportionalities among the represented distances while giving the viewer the impression of looking at part of the spherical surface of the globe.

Finally, Ptolemy wrote two large-scale works on scientific topics that had only tangential connection with astronomy. The *Harmonics*, in three books (of which the end of the third is lost), may have been his first major composition. It is an attempt to construct rigorous mathematical models based on ratios of whole numbers to describe the many systems of tuning musical intervals that were current in the Greco-Roman world of Ptolemy's time. The *Optics* is an investigation of the phenomena and theory of visual perception. It comprised at least five books, but only Books 2 through 4 and the beginning of 5 survive in a medieval Latin translation made by Eugene of Sicily from a lost Arabic translation.

Illustrations:

http://www.coinarchives.com/a/lotviewer.php?LotID=565232&AucID=1011&Lot=803&Val=a6c2d336a512cfa277ddea0f9cf9631b

Coin representing two concentric zodiacs, one of a series of zodiac-themed coins issued in Alexandria in AD 144/145 to commemorate the return of the Egyptian calendar to its original alignment with the solar year after 1461 years. Two years later, Ptolemy would erect a public inscription at Canopus near Alexandria announcing details of the astronomical system of his as yet unpublished *Almagest*. According to Galen, who studied medicine in Alexandria around this time, most of the experts in astronomy of his time lived there.

http://www.getty.edu/art/gettyguide/artObjectDetails?artobj=12548&handle=li
The earliest known portrayal of Ptolemy, on 6th century Byzantine silver plate. Ptolemy (left) and Hermes Trismegistus (right) debate with a celestial globe between them; the allegorical figure behind Ptolemy is Skepsis, "Rational Inquiry." The underlying conception may be the confrontation of reason and revelation as sources of astrological knowledge.

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http://www.onassisusa.org/transition/ebook/ (p.44)

Golden ring from Tartus, ancient Syria, inscribed with the horoscope of an individual born on August 17, AD 327. The positions of the heavenly bodies were computed using Ptolemy's tables, testifying to the success with which Ptolemy's *Almagest* and *Handy Tables* had supplanted earlier resources including methods of astronomical computation transmitted to the Greeks from Babylonia.