a. University of Cracow from 1491 to 1495, where studied astronomy, among other things
b. Canon law and astronomy in Bologna from 1496 to 1501, then medicine at Padua from 1501 to 1503, with degree in law from Ferrara in 1503
c. Astronomy a hot topic in both Bologna and Padua

3. We have comparatively little biographical information on Copernicus's efforts in astronomy -- indeed, not even on when and how he became so proficient
   a. Noted enough that Pope invited him to Rome in 1514 to comment on calendar reform that eventuated in the Gregorian calendar in 1582
   b. He refused, saying that motions of sun and moon had to be worked out correctly before appropriate to turn to calendar
4. Sometime around 1610 Copernicus formed the idea of the heliocentric system
   a. *Commentariolu*s summarizes system -- a manuscript that he circulated (date of composition unknown, but almost certainly no later than 1514)
   b. First section, included in the Appendix, lays out his motivation and axioms
   c. Spent much of the next 20 to 30 years developing complete heliocentric system, at a level of detail comparable to Ptolemy's *Almagest*
   d. Delay in publication not because of fears of Church, but because of fear of ridicule (see his prefatory remarks); probably also hoping to find some compelling evidence for his system
5. Rheticus came to work with him in 1539, published a summary in 1540, and arranged for full publication (in Lutheran Germany) of *De Revolutionibus* as Copernicus apparently preferred to call it
   a. Publication carried through by Osiander, who anonymously added preface saying just a hypothesis (undoubtedly out of fear of Lutheran Church, for Luther himself had dismissed Copernicus's heliocentrism when he heard of it)
   b. Legend has it that Copernicus saw printed book, or at least pages from it, on his death bed and was upset by the preface
   c. Whether this is true or not, Copernicus was definitely opposed to the idea that astronomical models should be regarded just as hypotheses used for calculations -- indeed, he was opposed to Scholastic nominalism quite generally, not just this one manifestation of it

F. Copernicus and Ibn al-Shāţir (d. 1375)
1. A chance discovery in 1957 of an Arabic manuscript by Ibn al-Shāţir (*The Ultimate Quest regarding the Rectification of* [*Astronomical*] *Principles*) in an Oxford University library has transformed Copernican scholarship -- and increasingly the historiography of Islamic science as well, though this transformation is still in process
   a. Before: Copernicus effected a mathematical transformation of Ptolemaic astronomy into a heliocentric system, in the process eliminating all violations of uniform circular motion as well as the error on the variation of the distance of the moon in that astronomy

b. But Ibn al-Shāţir in the manuscript had already eliminated all violations of uniform circular motion and the error on the moon in just the way Copernicus does
c. After: Copernicus effected a mathematical transformation of Ibn al-Shāţir's "rectified" version of Ptolemaic astronomy into a heliocentric system

2. Ibn al-Shāţir, though living in Damascus, was part of a school of astronomers centered at the observatory in Marāgha (Iran) founded in the thirteenth century and thriving until at least 1316
3. Ibn al-Shāţir's manuscript offers cinematic theories for the sun, moon, and five planets that amount observationally to Ptolemy's, but systematically eliminate all traces of non-uniform circular motion
   a. Replace the equant in the orbits of Venus, Mars, Jupiter, and Saturn with a small epicycle (along which the center of the major epicycle then moves) in a way (to be discussed later) that gives the same effect as the equant, but with a slightly different trajectory
   b. Offered an entirely new theory of the moon, using epicycles on epicycles to capture all three of Ptolemy's inequalities, in the process no longer having the variation in the distance of the moon from the Earth flagrantly violate the small variation in its apparent diameters
   c. Offered a new theory of Mercury in which the length of a radius vector varies during the course of its zodiacal motion, effecting the same approximation to an elliptical trajectory as Ptolemy had (but using the Islamic uniform circular motion device called al-Ţūsī's couple)
4. Copernicus adopts exactly same devices in the models of those orbits in his *Commentariolis* (even including a small epicycle instead of an eccentric) while eliminating the major epicycles in Ibn al-Shāţir's models by having them become the orbit of the Earth around the sun
   a. A mathematical transformation of Ibn al-Shāţir's models into ones in which the planets and the Earth are in orbit around the sun
   b. By the time of *de Revolutionibus* Copernicus switched to eccenters and modified his models a little for Venus and Mercury after realizing that a direct transformation doesn't quite work
   c. But save for some subtleties involving values of parameters (see Appendix), the models of Mars, Jupiter, and Saturn remained transformations, and the moon model remained Ibn al-Shāţir's
5. Swerdlow: the parallels are "too remarkable a series of coincidences to admit the possibility of independent discovery"
   a. Not just how (1) the equant was eliminated for Venus, Mars, Jupiter, and Saturn, but also (2) the new theory of the moon and (3) the new theory of Mercury recur in *Commentariolis*
   b. Evidence that Copernicus did not discover these independently from his giving an incorrect reason for one aspect of the new theory of Mercury
   c. We still do not know when and how Copernicus became aware of Ibn al-Shāţir's models, or even how well he understood them, given that he did not know Arabic
6. Has led now to viewing Copernicus not as the beginning of modern astronomy, but as the last figure in the ancient tradition, more specifically the last of the Marāgha school